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Art I.—*The Roasting and Treatment by Chlorine of Gippsland Auriferous Ores.*

By D. CLARK, B.C.E.

[Read 10th March, 1898.]

The chlorination plant at the Bairnsdale School of Mines was erected with the dual object of serving as a testing plant and as a means for training students in the treatment of complex ores on a considerable scale.

The inclined long-hearth reverberatory furnace for roasting and the Plattner system for chlorinating were adopted after consultation with Mr. Henry Rosales, M.E., as the best for illustrating in detail the various operations essential for successful treatment. The principal dimensions of the furnace are :—

Length of roasting hearth, 35ft. 6in.

Width, 4ft. 2in.

Height of centre of arch above hearth, 1ft. 11in.

Rise of arch, 4in.

Width of fireplace, 2ft.

Height of bridge, which is hollow and has air-holes at the level of the hearth above the firebars, 1ft. 6in., and 1ft. above hearth.

Slope of hearth, 1 in 9, with six rabbling doors, 13in. by 9in.

Owing to some misunderstanding when being built, the height of the roof above the hearth of the furnace was too great, and, though roasting may be satisfactorily performed and a temperature much higher than is necessary be obtained, a greater consumption of fuel is entailed, owing to the larger volume of air passing into the furnace and the greater distance of the roof from the hearth.

The auriferous ores which have been treated consisted usually of sulphides and sulpharsenides, together with heavy oxides concentrated either at our own works or in the district from which they came.

The following list will indicate the commoner minerals, and also serve to show the standard of the gold contained :—

District.	Metallic minerals in order of relative abundance.	Standard of gold per 100.
Mallacoota ...	Limonite, pyrite, bismutite	96
Bemm River ...	Arsenopyrite, pyrite, galena, blende ...	85
Mount Tara ...	Pyrite, limonite, barytes	80
Mount Wills ...	Pyrite, stibnite, arsenopyrite, argentite, cerargyrite	66 to 76
Cassilis	Arsenopyrite, blende, pyrite, galena ...	66 to 80
Haunted Stream	Arsenopyrite, pyrite, galena, blende ...	90 to 96
Deptford ...	Do. do. do. ...	96
Bullumwaal ...	Arsenopyrite, pyrite, galena, blende, and wad	70 to 95
Grant	Arsenopyrite, pyrite, galena, blende, and wad	96
Dargo	Arsenopyrite, pyrite, galena, blende, wad, and erythrite	96
Budgee	Arsenopyrite, pyrite, galena, blende, chalcopyrite	82
Walhalla ...	Arsenopyrite (needle pyrites), pyrite, bournonite, galena, blende ...	82
Wood's Point ...	Pyrite, arsenopyrite, stebnite, siderite	82 to 97

As a general rule, from 1 to 5 per cent. of concentrates is obtained from raw ore, yet in the case of the Cassilis lodes the percentage of metallic mineral contents may rise to 50 per cent. Parcels of concentrates from Glen Wills have contained 25 ozs. gold and 90 ozs. silver per ton, yet the usual returns, when crushing from ounce stone, will be from 2 to 5 ozs. per ton of concentrates.

The gold in the ore is an alloy of gold and silver, containing from 66 per cent. of gold to 97 per cent. in the highest grades; only very minute quantities of copper, iron, lead and bismuth are to be detected. Copper is certainly a natural alloying element, but iron and lead are probably oxides or sulphides mechanically mixed only.

As Mr. Howitt pointed out, the gold ratio is invariably higher when occurring in sedimentary formations than when associated with granites or diorites.

The separate parcels of ore are weighed and samples are taken and dried at 110° C., and carefully assayed. The total weight and value of each lot is thus determined. The ores are then blended according to their composition, care being taken to

keep pyrites in excess of arsenical ores, and largely in excess of antimony sulphides; blanket sand, containing a large amount of silica, serves to dilute the concentrated pyrites.

The mixture should be dried before introducing it into the furnace, otherwise it will be difficult to screen; and if damp lumps of ore pass in, these will be difficult to roast, since they do not break up and thus pass through the furnace unaltered. By screening through a sieve, containing 4 holes per linear inch, all scraps of iron, lumps of semi-oxidised ore and other injurious materials are eliminated, and the fine material is run through a hopper and spread out upon the floor in a layer about 4 inches deep. Since a perfect oxidising roast is needed, it follows that to perform this operation quickly, a copious supply of warm air is needed, and reducing gases should be excluded. On the other hand, if the upper end of the furnace containing the raw sulphides becomes too hot, these burn and generate a large amount of heat; if this action is not moderated, fusion cannot be prevented, and the sulphides are rendered practically unfit for subsequent treatment. If the temperature is rising too rapidly the air must be shut off, or raw blanket sand fed in until conditions are normal.

Free sulphur, sulphides of arsenic, and metallic arsenic sublime and pass into a current of air about 2 inches above the surface of the ore, where they burn with a characteristic livid flame, while underneath may be seen a conspicuous, wavy, brick-red flame, which I assume to be due to the colour of the volatilised sulphur and sulphides of arsenic. As soon as these reactions go on freely the ore is mobile, and when stirred will run like a liquid, since the various particles are buoyed up on a cushion of sublimed products.

The ore is stirred vigorously at this stage, and after all sublimation products have disappeared, it is moved on to the next hearth.

Opposite the second door the flame is emitted from the surface of the ore itself, yet the mass will scintillate brightly, if stirred; the rabbling is carried on at this stage as continuously as possible, since a large percentage of sulphur is eliminated by oxidation.

The same material, when moved to the next door, will only sparkle when dropped through a layer of hot air, and if left unstirred for any length of time a soft crust forms, which

ultimately penetrates the mass; sulphur at this stage is mainly eliminated, and the material may be thrown into wave-like ridges to expose as large a surface as possible to the air. When moved to the fourth door, no sparks may be seen on stirring, but the ore appears to be porous and offers resistance to the rabbling tools.

When opposite the fifth door the ore is only stirred occasionally, since the sulphides have practically disappeared, and all that remains to be done is to decompose any sulphate of iron formed, or to oxidise the magnetic oxide to the higher state.

After this the ore is moved down to the hottest part of the furnace, or next to the fire-bridge, care being taken to exclude reducing gases at this stage; a few minutes' exposure on this hearth is generally sufficient to decompose any injurious sulphates and to raise the whole of the iron to its highest state of oxidation. Should it be kept too long on this hearth, especially in the presence of silica, it is again reduced to the magnetic form, and afterwards will partly unite with silica to form a black sintery mass from which it is difficult to extract the gold. The temperature should on no account reach the melting point of the bullion to be treated, otherwise the gold will be transformed from a porous, spongy, well annealed state, in a condition readily attacked by chlorine, to a spherical form offering but little surface to be acted on. Another danger is that, in the case of limonite ores, which, though they open up and lose their combined water at a calcining temperature, yet, at too high a temperature, the mass closes again and seals up the contained gold.

Should the ore contain much zinc, arsenic, or antimony, or low grade bullion, the introduction of a small quantity of salt is beneficial on the last hearth; it has been found that from 5 to 10 lbs. is sufficient for a ton of ore, and if introduced and stirred vigorously into the ore, when heated up to about 800° C., all ferrous oxide is converted almost instantly into ferric oxide, while hydrochloric acid, chlorine, and volatile chlorides are given off in abundance; below this temperature no perceptible action goes on. The ore is discharged from the furnace almost immediately.

Samples taken all over the hearth, before introducing the salt and after withdrawing the ore from the furnace, show no losses of gold due to volatilisation. As a matter of fact, gold is very

slowly acted on by chlorine at a temperature of 800° C., while above that temperature it is more sensibly acted upon, and also at an increasing rate down to 300° C.

By continually attending to the furnace, it was found that the raw ore could be shifted from each hearth every 45 minutes, so that pyrites could be perfectly roasted in 4½ hours; and, generally speaking, a better roast may be obtained in that time than by keeping the ore longer in the furnace.

In order to find out the state of the ore on the various hearths, samples were taken just before the material was moved downwards. Unfortunately, samples opposite doors 4 and 5 were mislaid; but, on testing the others with an ordinary horseshoe magnet, it was found that the material was highly magnetic from No. 1 door down to No. 3. Nearly all works[1] on roasting of ores state that pyrites loses one atom of sulphur, and the oxidation of the remaining atom is through the agency of sulphuric anhydride uniting with ferrous oxide to form a sulphate, which is afterwards decomposed into ferric oxide and sulphuric anhydride. Such, however, has not been the case in our furnace; in it, after the distillation of the free sulphur and arsenic products, the material left consists of magnetic sulphide; after contact with the air it becomes magnetic oxide of iron, and finally, by heating in the air alone, it is transformed into the sesqui-oxide.

The quantity of magnetic material in samples taken from No. 1 floor, 20 %; No. 2 floor, 24 %; No. 3 floor, 22·4 %, which contained only 5 % sulphur; No. 6 floor, ·4 %, with no sulphur and no ferrous oxide. The quantity of sulphate of iron present at any stage was exceedingly minute, and, since the heat required for its decomposition was not reached before about the fifth hearth, it is plain that too much stress has been laid on Plattner's statement.

My present investigations show that very little sulphur is combined with the iron beyond the third floor of the furnace, and in order to more definitely establish what the main reactions are, samples are being collected from furnaces of various design for future testing.

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[1] **Roberts-Austin's Presidential Address to Chemical Section British Association, 1891; Peter's Modern American Methods of Copper Smelting, p. 170; Metallurgy of Gold, from Plattner's Metallurgische Röstprozesse, p. 231.—T. K. Rose; The Metallurgy of Gold.—Eissler, 4th edition, p. 207.**

In samples Nos. 1, 2, 3 there is a large quantity of iron in the ferrous state; but in No. 6 there is none, although the oxide is slightly magnetic. Professor Liversidge has noticed this, and called attention to J. Robbin's[1] experiment of heating black magnetic oxide until it turns red, when it is found to be still magnetic.

Many misleading statements[2] have appeared concerning the reactions in roasting furnaces, but it appears that arsenic may be eliminated from any metal so long as sulphur is in excess, and thus there is but little difficulty in roasting any arsenical ores. Antimony ores are more troublesome, since a non-volatile oxide often forms, yet if pyrites is largely in excess the reducing action of the volatilised sulphur tends to prevent highly oxidised forms of antimony forming, and favours the expulsion of antimonious oxide in a volatile form.

Blende, up to 15 per cent., has not offered any difficulties, since it is non-volatile and infusible and oxidises mainly to a sulphate, which, if desired, may be leached out. Some is roasted to oxide, and since this is readily acted upon by acids, it may be transformed partly into chloride by the addition of salt. The heat should never be raised to such a temperature as to decompose zinc sulphate.

Galena roasts quietly to sulphate of lead; this, at a high temperature in contact with silica, will evolve sulphuric anhydride and glaze the silica with an impermeable coat of silicate of lead. When present in quantities up to 5 per cent., no trouble was experienced except when roasted with salt, when chloride of lead formed.

Bismuth oxide passes through the furnace unchanged.

Copper pyrites. These minerals never amounted to 1 per cent. of the ore put in the furnace, and in small quantities give no trouble; a mixture of sulphate and oxide remains even after roasting at a high temperature.

Manganese oxides pass through the furnace and give no trouble; the cobalt which the earthy ones contain is converted into a sulphate.

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1 Iron rust possessing magnetic properties, A.A.A.S., 1892.

2 Wilson's Chlorinate Process.

Limonite evolves water and becomes spongy; but at too high a temperature it will contract.

Siderite evolves carbon dioxide and carbon monoxide, and becomes spongy ferric oxide.

The last three minerals should be treated by themselves on the last hearth of the furnace, since they require a temperature just sufficient to dehydrate them and render them fit for leaching.

Metallic iron is wholly oxidised if not in pieces over one-eighth of an inch diameter.

Barite passes through the furnace unchanged, and offers no difficulties.

When oxygen is supplied to ores in the manner suggested, there need not be any fear of antimoniates or arseniates interfering with subsequent work; nor would I recommend the addition of carbon to eliminate these. Some fine charcoal accidentally became mixed with a small parcel of roasted ore at our works, and it was found, in burning this out, that a great deal of ferric oxide became reduced to triferric tetroxide, which we could not convert back again into the higher form.

In order to test whether the material has been thoroughly roasted, several tests have been recommended. Kustel[1] recommends throwing the heated ore into water and then plunging a bright iron rod in; if the rod is darkened, then sulphates are still present.

Rose[2] has pointed out that this method is worthless, since it will not show the presence of sulphate of iron; he, however, suggests the addition of barium chloride as a test for sulphates. But this test is also valueless, since sulphate of zinc, or sodium, may exist in an ore without interfering with the action of chlorine; and when it is considered that sulphuric acid in certain cases is actually mixed with the ore, it is certainly not necessary to test specially for this.

Eissler[3] recommends the use of ferrocyanide of potassium to a solution of any salts in the ore, to which there is no objection; but it should be pointed out that cobalt and nickel salts will give a greenish precipitate with this re-agent. The main objection to

1 Roasting of Gold and Silver Ores, San Francisco, 1880.

2 The Metallurgy of Gold, Rose, p. 229.

3 The Metallurgy of Gold, Eissler, p. 279.

Eissler's test is that it occupies some time and is not always performed properly, while, further, it only applies to soluble salts.

For a practical test, I consider the magnet gives a better clue to the state of the material in the furnace than any simple test recommended, the temperature at the time being high enough to decompose any ferrous sulphate. A sample can be readily taken from the furnace with a semi-cylindrical iron tube, emptied on a fire-clay tile, and the magnet run through it, when, if only a very small quantity adheres, the ore is sufficiently roasted.

Another test would be to make up a dilute solution of salt, sulphuric acid, and a few crystals of permanganate of potash, slightly stronger than that recommended by Professor Black. If it is decolourised on adding the roasted ore to it, then this is not sufficiently oxidised.

When the ore is removed from the furnace, the chloridising action of the salt, if added, still goes on, and the roasted material remains red-hot under a thin black crust for some hours. If this crust is broken, hydrochloric acid, volatile chlorides, and free chlorine escape. Tests were made of a considerable quantity of the ore, to determine whether any chloride of gold had condensed on the crust; but the results were negative. Neither could silver chloride be detected; but in the latter case the amount present must have been very small and might have escaped detection.

The ore remained on the brick cooling floor until almost cold; it was then moistened with water in sufficient quantity to make it adhere when pressed, but when released to fall to pieces. The smaller the quantity used the better for successful working.

The ore vats are lead-lined, with false bottoms and a gravel filter-bed below; both the filter-bed and the leaden sides are protected by wooden staves, which, together with all the internal woodwork, have been dried, warmed, and dipped in a molten paraffin bath.

The damped ore is fed into the vat through a sieve having 5 holes to the linear inch and is distributed evenly in layers with a garden rake, no packing being done; when full, the ore is pressed tightly around the edge of the vat to prevent chlorine escaping up the side, and the ore is raked away slightly from the

centre towards the circumference. If the false bottom is wet before charging the ore, dry ore should be sieved in until no more moisture is drawn up by capillary action.

The chlorine first used was generated from sulphuric acid and chloride of lime, but since it was impossible to get an even flow of gas, we discarded these and used liquid chlorine, prepared in Germany and exported in the usual steel cylinders, with 33⅓ lbs. of chlorine in each. These work so well that if the cost were not so great (chlorine 1s. 6d. per lb.) they would be largely used.

The chlorine from the cylinders is turned on and passed through a wash-bottle, so that the rate of flow can be regulated; from the wash-bottle it is conveyed to the centre of the false bottom of the vat.

The valve is turned so that chlorine can escape and pass through a half-inch pipe against a head of one inch of water at the rate of 6 bubbles per second. Yet at this speed it takes 6 hours to reach the surface of the ore. The cover is then lowered, a water-joint at the circumference of the vat making a perfect joint.

The valve is now turned down, so that a bubble may pass through the wash-bottle every 3 seconds, and this is continued until there is no back pressure. Stress was laid by early writers on chlorination about the necessity of separating hydrochloric acid out with wash-water, and speculations were common as to its injurious effects on the process. T. K. Rose[1] has shown the absurdity of the arguments brought forward.

It was found that during the passage of the ore the pipes became blocked up on cold nights, and, on investigation, the solid substance proved to be chlorine hydrate. The expansion of the gas on being released was sufficient to cause the cylinders to become frosted over in a few hours. It was also found that watery vapour diffused back into the chlorine, and this started to corrode the valves. These difficulties were overcome by using strong sulphuric acid in the wash-bottle.

The ore is allowed to remain for 48 hours in contact with the gas, and at the end of that time samples are taken from top to bottom, and the gold chloride is washed out. From 2000 to 3000

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1 The Metall. of Gold, p. 253.

grains of the leached sample are then taken and assayed, and if the returns show that from 2 to 4 dwts. are left in, according to the richness of the original sample, then the cover of the vat is raised and a spray of water under a pressure of about 20 feet from a rose is allowed to fall over the surface of the ore.

In this way most of the chlorine present is absorbed and carried down to the bottom of the vat. As soon as the liquid reaches the bottom, the lower tap is turned on and it escapes into the precipitating vat. Practically the first few gallons, when washing is done in this way, contain most of the gold.

When the surface of the ore, which has subsided by about a fifth of its height, is again above water, another shower is sprayed over it, and so on until the escaping liquid is free from gold.

By washing in this way, it will be found that wash-water less than half the bulk of the ore is sufficient to carry all soluble gold out; it also offers a further advantage: that should any solid reducing agent be present accidentally—say an iron bolt—almost the whole of the gold will be washed past without much danger of local precipitation; whereas, if the vat were filled in the orthodox way, undesirable secondary actions would go on for a considerable distance around the metal.

The auriferous solution is allowed to flow through an open-texture canvas bag, which serves to retain any sand, sulphate or chloride of lead, or other solid material which may have passed through.

The gold solution is tested with sulphate of iron in a porcelain basin, the slightest discolouration being made plain against a white surface.

Many authorities recommend stannous chloride, containing a small quantity of stannic chloride, as a more delicate test; but it is found in practice to fail, and is not so certain as the ferrous sulphate method.

The amount of chlorine used for each ton of ore was determined by weighing the cylinder before and after each operation, and it was found to vary from 6 lbs. to 10 lbs. of chlorine per ton of ore. On several occasions the ore was charged in hot, and it was found that more chlorine was required and the extraction performed in the same time as when cold. The escaping liquor contained much larger quantities of base chlorides than when cold.

It would therefore appear that, though gold is more readily attacked by hot chlorine than by cold, the same is the case with other materials also, and on a large scale; so that there is a positive disadvantage in charging the vats with hot ore. The extractions obtained from a large number of parcels varied from 93 per cent. to 97·6 per cent. of the gold contents.

Tests were always made in the laboratory on a few pounds of the roasted ore, to determine the amount of chlorine to be used, the time of contact to be allowed, and the extractions; and these afforded an infallible guide as to results on a larger scale, with the exception of time. It was found that while 24 hours might serve for a laboratory test, it took double that time to get the same result from some tons of material. It was also found that while the rate of dissolution went on rapidly at first, it became slower and slower, and in course of time practically ceased; so that there is a limit to the amount of gold to be extracted in a given time.

No difficulty has been experienced up to the present in treating the low-grade bullion mentioned before, although most writers have judged it would be difficult to deal with by chlorination.

When the whole of the wash liquor has been drained into the precipitation vat, there is usually enough lead present in solution to form a precipitate when sulphuric acid is added. Sulphate of iron solution and sulphuric acid (the latter to prevent the precipitation of basic sulphates) are added and stirred well; the precipitate formed—gold and sulphate of lead—falls rapidly, but is allowed to settle for 24 hours. The supernatant liquid is then tested, to see if any gold is still in suspension, and if there is none, the liquor is siphoned off, one leg of the siphon being attached to an india-rubber tube kept near the surface of the liquid by means of a float, and the other discharging into a mixture of sawdust and charcoal in an earthenware cylinder.

A solution of auric chloride is used to test the liquid draining off at different levels, as it sometimes happens that the upper layers may have excess of sulphate of iron and the lower ones still contain dissolved gold.

When the liquor has drained to within three inches from the bottom of the precipitate vat, the siphon is withdrawn, and the auriferous sludge washed out with a fine jet of water into a deep

earthenware vessel; it is allowed again to settle and the top liquor siphoned off, and, finally, the precipitate is emptied into a filter placed within a large funnel; after it has drained, the whole is dried in an iron dish, nitre sprinkled over it to help to oxidise the filter-paper, and then heated to burn out the organic matter.

The dried material is finally smelted down in a clay pot with the addition of borax. The gold thus obtained is almost pure. The slags are melted down with carbonate of soda, carbon, and litharge, and large cupels are made to hold the lead so reduced, which is then cupelled in the usual way.

In addition to the Plattner process, carried out as before described, a dilute solution of chlorine has also been used, but the extractions obtained were not quite so good as with the original method.

A trial was also made of the Etard-Black process, the details of which were kindly supplied to me by Mr. Stone, of the Government Analytical Laboratory. It was found that the quantities specified, viz.:—1st solution, water, 50 gals.; sulphuric acid, 14 lbs.; 2nd solution, water, 50 gals.; salt, 15 lbs.; permanganate of potash, 6 ozs.—gave too weak a solution to be used with ordinary roasted ores, but on increasing the amount of permanganate to about 24 ozs., and allowing the liquor to percolate slowly through the ore for 60 hours, 96 per cent. of the gold present was extracted. There does not appear to be any special advantages in the method over a dilute chlorine solution. It might be possible, however, to precipitate the gold on charcoal, and by oxidising the liquor again with permanganate, or other re-agents, it could be used over again. In that case the only waste would be due to the sulphuric acid used in dissolving base metals and the permanganate used each time.

Tests have also been made on the roasted ore with dilute cyanide of potassium solutions with highly satisfactory results, and it appears to me that, with proper handling, almost any roasted ore may be treated successfully with the cyanide solutions, with the further advantage that the silver is also recovered. Should the cyanide prove as effective as chlorine as a solvent for gold in roasted ores, then chlorination will soon be a method of the past.

The silver contents of our ores, when mixed, never amounted to more than 5 ozs. per ton, so that silver was not specially worth troubling over, though in the laboratory we could extract from the tailings about 60 per cent. of their contents with a hyposulphite solution, and 80 per cent., as well as a small quantity of gold, with a cyanide solution.

Repeated efforts were made to see if gold could not be recovered by amalgamation from the roasted material, but 75 per cent. was the utmost that could be obtained. The tailings from the chlorination vats were also tried, but only 25 per cent. of their gold would yield to amalgamation processes. It is exceedingly difficult to amalgamate very fine gold, even when it is free.

It is evident, though numberless modifications have been suggested, many of which have been carried out on Plattner's original method, that for simplicity and applicability to almost any ore it need never have been departed from.

Art II.—*Further Descriptions of the Tertiary Polyzoa of Victoria.—Part I.*

By C. M. MAPLESTONE.

(Plates I. and II.)

[Read 12th May, 1898.]

At the suggestion of Professor Spencer, I have undertaken to continue the examination of the fossil polyzoa found in the Tertiary strata of Victoria, and thereby supplement the work of the late Dr. Macgillivray, whose valuable Monograph appeared in the Transactions of this Society; and I would remark that it is with the greatest pleasure I do so, now that I have time to devote to the work, for from 1866 until 1884 I studied the recent polyzoa, and during all that time received great assistance from Dr. Macgillivray. Afterwards my official duties necessitated constant travelling, and I had to discontinue working at them; so I gave my undescribed material to him, and I have pleasing reminiscences of evenings spent at Bendigo with him in the examination and discussion of new species.

Thanks to the kindness of Mr. T. S. Hall and Mr. J. Dennant, I am in possession of material collected from many localities, which has yielded me, so far, the majority of the species already recorded, and also many new forms. The present paper deals with some new species of Catenicellidæ, together with some oœcia (of known species) which have not hitherto been described.

Though I am quite aware of the evil of making unnecessary species, I have described the fertile zoœcia of Catenicellæ and Strophipora which I have found as new species, because, as all the fossil specimens are in single internodes, in consequence of the corneous connecting tubes being destroyed, it is impossible to determine whether they are oœcia of known species or not; for those in the recent and, presumptively, also those in the fossil species differ considerably from the form of the normal or infertile zoœcia. In the Claviporellæ and Caloporellæ it is different, as the oœcia in these genera are adnate upon, or

conjoined to, normal cells; consequently, I have been enabled to assign two of those I have found to species already described.

The type specimens will be deposited in the National Museum.

Catenicella orbicularis, n. sp. (Pl. I., Fig. 1).

Zoœcium very large, orbicular, the front slightly flattened, occupied with a series of large, irregularly shaped, tubular fenestræ diverging from a central line to the margin, mostly broken away, and separated by shallow grooves. Lateral processes small, with a large avicularium at each upper angle of the zoœcium and a narrow long infra-avicularian depression. Thyrostome arched above, slightly curved below.

Locality.—Balcombe Bay, Mornington. (T. S. Hall).

I have found only one specimen of this species; it is allied to *C. latifrons*, but is at once distinguished therefrom by its large size and nearly spherical shape.

Catenicella macgillivrayi, n. sp. (Pl. I., Fig. 2).

Zoœcium (fertile only found) small, semi-globose, with seven small fenestræ; lateral area broad, smooth, with an extension at one upper angle, which may be avicularian. Oœcium oval, with a slightly depressed falciform, granular area in each side. Oœcial aperture semicircular above; lower lip sinuous, with a small sinus in the middle. There is a projecting tube above the oœcium, which possibly may have borne an avicularium.

Locality.—Muddy Creek. (T. S. Hall). A single specimen.

This species and the next are of the usual type of oœcia of Catenicellæ, of which none have hitherto been found fossil.

Catenicella spenceri, n. sp. (Pl. I., Fig. 3).

Zoœcium (fertile only found) broad, subtriangular with four fenestræ. Lateral processes wide. Oœcial aperture very broad, semicircular above; lower lip wide, sinuous, having a shallow sinus in the centre. Oœcium large, oval, with two large, reniform depressed areas, with raised upper margins on the front; above the oœcium is a plate with two perforations, which is not perfect; it was accidentally broken in the mounting, one perforation only is left.

Locality.—Muddy Creek. (T. S. Hall). A single specimen.

Catenicella dædala, McG. (Pl. I., Figs. 4 and 5).

Dr. Macgillivray mentions only geminate pairs of this species. I have found single zoœcia.

Locality.—Balcombe Bay, Mornington. (T. S. Hall).

Some of my specimens are evidently in a more perfect state than the one figured in the Monograph (Pl. I., Fig. 28), the avicularium being clearly defined, and apparently with the mandible *in situ*. The ridges between the infra-avicularian and pedal depressions and around the fenestrate area are very prominent. An outline (Fig. 5) is given to show the great dorsal rotundity.

Catenicella elegantissima, n. sp. (Pl. I., Fig. 6).

Primary and lateral zoœcia ovate, with 5·7 fenestræ in a scutiform area; lateral processes wide. In the upper zoœcium there is a ridge extending upwards from the thyrostome, with two branches at right angles to it; thyrostome arched above, straight below; there is a small round pore below each lower angle, and between them a small semicircular elevation. In the lateral zoœcium the thyrostome is arched above, nearly straight below, with the upper part of the peristome slightly raised; a ridge extends upwards and branches similar to, but not exactly like, that in the upper zoœcium. The oœcium is adnate to the zoœcia (a condition rarely found in true Catenicellæ); it is large, ovate, with two large depressed, granulated areas, separated by a vertical ridge.

Locality.—Balcombe Bay, Mornington. (T. S. Hall).

This is a most interesting specimen, as it consists of three zoœcia and an oœcium in one internode. It and *C. porosa* (McG.) form a new and distinct type of the genus Catenicella as defined by Dr. MacGillivray. I have only seen one specimen.

Caloporella grandis, n. sp. (Pl. I., Fig. 7).

Zoœcia elongated, obconical, with broad vittæ having two rows of pores. Thyrostome lofty, arched above. Lower lip slightly curved. Avicularian processes large, with arched rostrum.

Locality.—Muddy Creek. (T. S. Hall).

There is in the specimen an oval hole through the cell wall, with smooth sloping edges, near the thyrostome, which has apparently been made by a small carnivorous univalve mollusc. This is quite probable, as in my search for fossil polyzoa I found many such molluscs, much smaller than a zoœcium of a Catenicella. There is also a small chlithridiate depression near the upper angle on one side; the upper portion of the other side is broken away.

This is allied to *C. speciosa*, having two rows of pores; but it is much larger, and the avicularian processes are different.

Caloporella dendrina, n. sp. (Pl. I., Fig. 8.)

Zoœcium (fertile only found) subtriangular; lateral processes broad, with avicularia at upper angles Front raised, smooth. Vittæ very narrow. Thyrostome lofty, arched above, straight below. Operculum (which is *in situ*) of same shape. Oœcium surmounting zoœcium, ventricose, with broad, punctate ridge surrounding it; front surface smooth, with linear depressed, dendroid markings ramifying from a central one.

Locality.—Muddy Creek. (T. S. Hall).

I have only seen the one figured; it is particularly interesting, as the operculum is *in situ*, a circumstance which I believe has not before been noted in the fossils.

Caloporella cordata, n. sp. (Pl. I., Fig. 9.)

Zoœcia (fertile only found) obconic, with small spatulate, lateral vittæ having only a few pores in two rows. Thyrostome of upper zoœcium arched above and below, with a denticle on each side. Oœcium cordate, adnate to zoœcia with a falciform, depressed area on each side; the aperture is arched above, sinuous below, with a small sharp sinus.

Locality.—Muddy Creek. (T. S. Hall). A single specimen.

Caloporella maculata, n. sp. (Pl. I., Fig. 10).

Lower zoœcium subtriangular, smooth, with wide lateral processes. Upper zoœcium elongate, with wide lateral processes;

The oœcia of this species (*C. longicollis*) I have in two distinct forms. All my specimens, except one, show a form similar to Fig. 14, which is drawn from the most perfect one. The oœcium is adnate on a geminate pair, or rather triplet; it is globose, covered with tubercles, which are more raised on the periphery than in the central portion. The zoœcia are of the form of Fig. 24, Pl. II. (Monograph), and, in addition, the upper one has two small tubular spines, very similar to some of the recent Claviporellæ. The other form (Fig. 15) is that of the variety named by Dr. Macgillivray *angusta*. The oœcium is globose, with an avicularium on its summit; it is quite smooth, and there are only two zoœcia in the internode. There is a pore on each side, a little below the thyrostome, in the lower or primary zoœcium. Now that the oœcium is found, and is so different from that of Fig. 14, I assign specific rank to this variety.

Localities.—Claviporella longicollis, Moorabool. (T. S. Hall). *Cl. angusta*, Muddy Creek. (T. S. Hall).

I have several specimens of oœcia of *C. longicollis*, but only one of *C. angusta*.

Calpidium morningtoniensis, n. sp. (Pl. II., Figs. 17 and 18).

Zoœcium elongate, with five fenestræ. Lateral processes narrow, flattened on the sides, with large conical avicularia in the upper angles. Thyrostome arched above, with a curved, raised extension of the outer peristome above and at the sides similar to the hoods of *C. ornatum* and *C. ponderosum*, very prominent at the sides, but not so fully developed at the top; inner peristome (thyrostome) slightly thickened. The lower lip is broken away.

Locality.—Balcombe Bay, Mornington. (T. S. Hall). A single specimen.

This genus has not hitherto been found fossil. The lower lip being broken, it is impossible to say if the thyrostome is chlithridiate, as it is in the two recent species.

Fig. 18 is a sketch of as much of the side as could be seen by tilting the slide.

Ditaxipora internodia, Waters, sp.

I wish to note that I have found specimens of this species which agree with Mr. Waters' description (Q.J.G.S., Aug., 1881, p. 318) in having an oval space below the thyrostome, formed by the spreading out of the central band and a pore in it, which were apparently not present in the specimens which came under Dr. Macgillivray's notice. I have also found some which agree with the description in the Monograph. They must be considered as varieties merely; there is not sufficient difference between them to justify specific separation.

I include in this paper a description and figure of a very interesting form, which, though not belonging to the Catenicellidœ, I wish to bring under notice now, on account of its very extraordinary nature.

Schizoporellopsis, nov. gen.

Zoœcia of two forms in longitudinal series. Upper zoœcium elongate; thyrostome subcircular; sinus in lower lip. Lower zoœcium oval; thyrostome semicircular, no sinus in lower lip.

Schizoporellopsis abnormls, n. sp. (Pl. II., Fig. 13).

Upper Zoœcium elongate, front granular, perceptibly convex over a large oval area below the thyrostome; margin thickened, extending upwards to the middle only of the thyrostome; thyrostome subcircular with a sinus in the lower lip; peristome thin, raised. Lower zoœcium oval, somewhat pointed below; margin thick; central area depressed; surface granular, with a small circular area, slightly elevated in the lower part; thyrostome arched above, straight below, without any sinus.

Locality.—Muddy Creek. (T. S. Hall).

This is a very puzzling form, as it consists of two zoœcia which, if separate, would be relegated to different genera, or, indeed, families. I have examined it most carefully; there is no doubt as to the continuity of the cell walls, and the zoœcia are in the same plane, not one superposed upon the other. I have found only the specimen figured. It apparently forms a connecting link of a very peculiar nature between the families of Schizoporellidæ and Microporidæ.

Note.—The paragraph on page 8 in Dr. Macgillivray's Monograph, commencing "The extended lateral processes," should follow the next one describing the genus Catenicella, and should appear on page 9, as it is only applicable to that genus, and not to the *family* of Catenicellidæ.

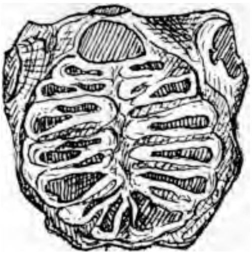
EXPLANATION OF FIGURES.

Plate I.

Fig. 1.—Catenicella orbicularis.
„ 2.—C. macgillivrayi.
„ 3.—C. spenceri.
„ 4.—C. dædala, single zoœcium.
„ 5.—C. dædala, side view.
„ 6.—C. elegantissima.
„ 7.—Caloporella grandis.
„ 8.—C. dendrina.
„ 9.—C. cordata.
„ 10.—C. maculata.

Plate II.

Fig. 11.—Caloporella enormis.
„ 12.—C. rostrata.
„ 13.—Schizoporellopsis abnormis.
„ 14.—Claviporella longicollis.
„ 15.—Cl. angusta.
„ 16.—Strophipora bellis.
„ 17.—Calpidium morningtoniensis.
„ 18.—C. morningtoniensis, side view.



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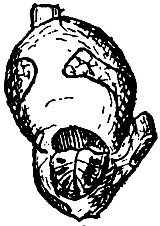

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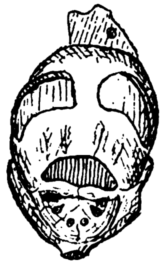

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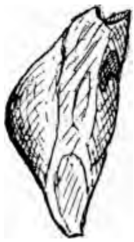

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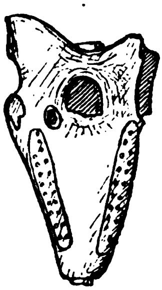

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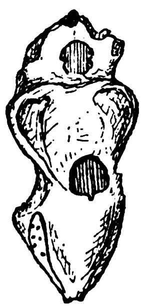

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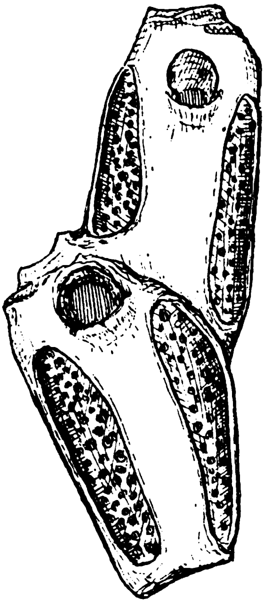

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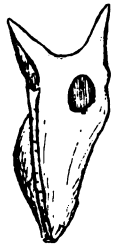

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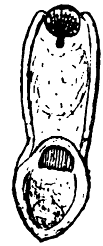

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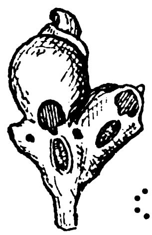

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Art. III.—*The Occurrence of So-called Obsidian Bombs in Australia.*

By R. H. WALCOTT, F.G.S.

(Plates III. and IV.)

[Read 9th June, 1898.]

In writing this paper I have been mainly influenced by a desire to draw attention to these most interesting and, in many respects, remarkable objects, in order, if possible, to satisfactorily solve the mystery surrounding their origin. It is, without doubt, a subject which presents many difficulties, and I do not purpose attempting an explanation to account for them, simply because at the present time sufficient data are not obtainable to establish definitely any acceptable theory. I will, therefore, only discuss the explanations put forward by others, and give the conclusions which I have drawn from my own observations. The term "bomb" has been generally applied to these objects, but I think it is justly open to objection, inasmuch as it conveys the idea of a terrestrial volcanic body; and as we have no positive proof that they are products of this nature, the name may be misleading. As long as this uncertainty exists, some other name would be more appropriate, and I suggest and will refer to them in this paper as "obsidianites," a term which will at least not be open to this objection, and will be more convenient for use. As far as can be ascertained, little seems to have been done in the past towards unravelling the true nature of obsidianites—no doubt owing to the obstacles which are at once encountered. They appear to have been first mentioned by Charles Darwin,[1] who described a button-shaped specimen which had been given to him by Sir Thomas Mitchell. It was found on a great sandy plain between the rivers Darling and Murray, and at a distance of several hundreds of miles from any known volcanic origin. He states: "It seems to have been embedded

[1] Geological Observations on Coral Reefs, Volcanic Islands, and in South America, 1851 ed., pp. 38, 39.

in some reddish tufaceous matter, and may have been transported either by the aborigines or by natural means. The external saucer consists of compact obsidian, of a bottle-green colour, and is filled with finely-cellular black lava, much less transparent and glassy than the obsidian."

Darwin also mentions some obsidian balls described by F. S. Beudant,[1] which are never more than six or eight inches in diameter, and are found strewn over the surface of the ground. Their form is always oval; sometimes they are much swollen in the middle, and even spindle-shaped. Their surface is regularly marked with concentric ridges and furrows, all of which on the same ball are at right angles to one axis; their interior is compact and glassy. Beudant supposes that masses of lava, when soft, were shot into the air, with a rotatory movement round the same axis, and that the form and superficial ridges of the bombs were thus produced.

The Rev. W. B. Clarke,[2] in speaking of the specimen described by Darwin, says that it would seem either to have been drifted from a very long distance, or, which is more likely, from the known habits of the aboriginals, to have been dropped by one of them, who probably found it in the trap hills of the Lachlan, to the north eastward. This specimen was unique as to Australia until recently (at time of writing). The first which Mr. Clarke met with was found in the cradle of a gold-washer on the Turon River, who dug it from a depth of thirty feet below the surface. A somewhat similar specimen was found in the washing-stuff of the Uralla or Rocky River, county of Hardinge, New England District. From the same locality two other specimens were derived. They appear as if they had been cast in a mould; but there is no reason to doubt the imputed origin.

With regard to the Uralla specimens, Mr. Clarke thinks it possible, from the contour of the country and the geological structure, that they had their origin in an outburst of trap (basalt) which caps the ranges in the neighbourhood, and has issued from and overflowed the granite. He considers this more satisfactory than associating them with an intrusion of various

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1 Voyage Minéralogique et Géologique en Hongrie, 1818, tom. ii., p. 214.

2 On the Occurrence of Obsidian Bombs in the Auriferous Alluvia of N.S.W. Quarterly Jour. of Geol. Soc., vol. xi. (1855), p. 403.

trappean, porphyritic, and trachytic rocks which occurs about four miles further south, because the detritus is all local and there is no easily assignable crater.

"Whether this explanation is sufficient or not, the facts themselves are interesting, for these singular bodies have been found in three localities in Australia, at intervals of 455 and 205 miles apart—the distances from the Murray and Darling Plain to the Turon, and from the Turon to the Uralla. That they could have had only one point of origin is scarcely to be supposed, if they are really of sub-aërial volcanic origin. In two of the three localities, at least, there is presumption of such action; and in both of these localities the bombs are embedded in gold deposits."

In the Melbourne Intercolonial Exhibition Catalogue,[1] 1866, mere mention of their occurrence is made as being abundantly distributed over the surface of the basaltic plains round Mount Elephant and Mount Eeles[2] (? Eccles), and on the tertiary mud plains of the Wimmera, far removed from any known basaltic craters or points of eruption. Some analyses are also given, but will not be referred to now. In the descriptive catalogue of the rock specimens and minerals in the National Museum, 1868, mention is made of a remarkable obsidian ball found in the Upper Regions Station, Horsham. On account of its low specific gravity, 1·06, it was deemed advisable to have it cut, but unfortunately no means were taken to collect the enclosed gas. It now shows a cavity having a beautiful polish, and may be seen in the collection of Victorian minerals in that Museum. This specimen will be fully dealt with subsequently.

Professor Tate[3] inclines to the opinion that their distribution has been effected by human agency, and mentions that they are held in high estimation by the aborigines, but considers that the

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1 Notes on the Physical Geography, Geology and Mineralogy of Victoria, by Alfred R. C. Selwyn and George H. Ulrich, p. 65.

2 No such mountain is known in Victoria, and it is presumed that Mount Eccles is meant. Prof. Ulrich, who was at that time engaged on the geological survey of the colony, says that the name was given to him by Mr. Selwyn, who collected a number of obsidian buttons there, but that if a basaltic point named Mount Eccles is given on the maps situated on the western plain towards Warrnambool and in the neighbourhood of Mount Elephant, we would be justified in concluding it to be the correct one. There is no doubt that the names apply to the same mount, as in Selwyn's map Mount Eeles is in the position given to Mount Eccles in other maps.

3 Trans. Philosoph. Soc. Adelaide, S. Aust., vol. ii. (1879), pp. 70, 71.

evidence is not conclusive till they shall have been traced to their natural sites. He says they have been collected at distant parts of the colony, occurring either loose on the surface or embedded in the "crust limestone."

Mr. H. Y. L. Brown, in the Catalogue of South Australian Minerals, 1893, states that obsidian "has been found in alluvium and on the surface generally in round, button-shaped pieces all over the province, although most frequent in the stony downs and table-hill country of the far north, where its presence, so far away from any volcanic centre, is most difficult to account for."

Victor Streich,[1] who was geologist to the Elder Exploring Expedition, states "that two specimens of the well-known obsidian bombs, and of the usual shape, were collected, one at Birksgate Range and one near Mount Squires. No clue could, however, be obtained as to the original site, or in explanation of their wide-spread occurrence." In some supplementary notes to this paper on the rock and mineral specimens collected, Professor A. W. Stelzner, in dealing with the obsidian bombs found between Everard Range and Fraser Range, says that they are "most decidedly not of cosmic origin, as suggested by you in your private letter to me. At least, so far there are no vitreous masses known to me of meteoric origin. According to their shape, I am inclined to pronounce them as water-worn, and I should think that the obsidian, from which they are derived, will be found yet *in situ*. I cannot say anything more about them without any knowledge of their occurrence."

Subsequently Professor Stelzner received other specimens for examination and further information, and as a result he published an elaborate paper[2] on the subject. He also wrote a lengthy letter to Victor Streich, who had forwarded the obsidianites to him. Five of these were collected at the McDonnell Ranges and the sixth, a hollow one, was found on Kangaroo Island. The substance of the letter is practically the same as the paper, and therefore need not be specially referred to apart from it. Professor Stelzner, who believes these objects to be genuine volcanic bombs, points out certain resemblances to the Bohemian

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1 Trans. of Royal Soc. of S. Aust., vol. xvi. (1893), p. 84.

2 Ueber eigenthümliche Obsidian-Bomben aus Australien. Zeitschrift der Deutschen Geologischen Gesellschaft, xlv. Band, 1893, p. 299.

moldavites,[1] and that the origin of both is enveloped in mystery, but does not think the comparison admissible, as he believes the moldavites' surface sculpture is secondary, whilst the Australian specimens is primary; and, further, that the moldavites possess most variable shapes, and therefore can only be regarded as fragments of larger bodies. The reason which induces him to accept their volcanic origin is based upon the undeniable conformity of general form which the specimens examined exhibited. With regard to the hollow specimen, he says that an exact parallel case of such a natural glass is not known to him either from literary descriptions or from collections, but one is reminded of certain bombs formed of pumiceous material as something nearly akin; for example, the glass balls of black, floating pumice observed by Leopold von Buch[2] in the tuff rocks north of Rome. He also mentions the volcanic bombs from Ascension described by Darwin. He discusses and dismisses the comparison with marekanite from Ochotzk. This is a pitchstone, with kernels of obsidian, from which the latter have become freed by weathering. In referring to other analogous cases, he gives a sentence which occurs in a review of the work of W. Stokes.[3] It is as follows:—"Drops of Vesuvian lava are said to have been found sometimes, and of perfectly globular form. Generally, though they appear somewhat flattened and elongated, at the same time they are surrounded by a projected zone studded with small knobs. These deformities depend upon the degree of viscosity of the descending mass, and the nature of the ground upon which such specimens alighted. Forms resembling these are produced by the rim cooling first." Reference is

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[1] Professor Rutley (Quart. Jour. of Geol. Soc., vol. xli. (1885), pp. 154, 155) says that Bouteillenstein (Moldavites) occurs in small, irregularly-shaped nodules and grains in sand near Moldauthein, in Bohemia, in tuffs in the neighbourhood of Mont Dore les Bains and Pessy in the Auvergne, and in one or two other localities. These nodules have peculiarly pitted, corrugated, or wrinkled surfaces. That Bouteillenstein is obsidian is denied by Makowsky (Ueber die Bouteillensteine von Mähren ū Böhmen, in Min. Mittheil, vol. iv., p. 43). Prof. Rutley considers the comparison of Moldavites with fulgurites not merely admissible, but positively instructive. However applicable it may be in that case, I do not think it can be applied to obsidianites.

[2] Geognostiche Beobachtungen auf Reisen durch Deutschland und Italien, 1809, ii., p. 51.

[3] Ueber Kugelige Bildingen mineralischen substanzen, Neues Jahrb, f. Min. etc., 1836, p. 78. Also Jour. of Geol. Soc. of Dublin, vol. i., pp. 1-15.

also made to the obsidian balls from Mount Patko, Hungary, previously mentioned as being described by F. S. Beudant.

Darwin considers the form of the bombs to be due to rotatory flight, in the centrifugal force engendered thereby, and in the final bursting of the bomb; but with this view Professor Stelzner does not agree, and he regards the final bursting as really objectionable. He admits, however, that rotation may have taken place, although he does not think it necessary.

According to him, the outline form of five specimens can be deduced from that of a sphere, and that of one to a triaxial ellipsoid. He considers that the approximately spherical form was produced in two very different ways. In the one case—that of the hollow ball—it has been produced by the expansion of a thread of lava rich in gaseous components; in the six solid bombs the form is referable to the same causes which induce the shape of a drop of water, or fluid lead descending from a tower or into a shaft, and forming shot globules. He further states that the shape must have been likewise influenced by the resistance of the atmosphere which the rapidly moving bomb had to surmount. In this the explanation of the special form and the more delicate surface sculpture has to be sought for. He then goes on to compare the obsidianites with meteorites, and considers it perfectly admissible. In this he mentions the black, glassy crust, the pittings and the analogy to the expansion rims and streaked friction planes which Daubree[1] obtained in his experiments. Finally, he thinks their origin is to be sought for in Australia, but leaves it to Australian geologists to settle.

Professor Tate and J. A. Watt, in their report on the Geology of the Horn Expedition, 1897, in referring to the numerous obsidian bombs, which most frequently occur in an eroded state, and unrolled agates found between the Stevenson River and Charlotte Waters, say—"In the first place, the occurrence of (*sic*) the obsidian bombs and agates on the Desert Sandstone plateaux and their slopes could not have been transported there by water, unless in the form of ice (an hypothesis incompatible with the co-ordinate features)." They therefore assume that these agates and bombs are all that now remain of a supposititious

1 Etudes synthétiques de géologie expérimentale, 1879.

volcanic formation, but admit that "the theory seems wild in the extreme, because of the widespread silicification, and the absence over its area of any traces of actual volcanic outbursts."

In "Nature" of 13th May, 1897, there is a review of a paper[1] by Mr. R. D. M. Verbeek, in which he dealt with the glass balls of Billiton:—"In the quaternary or, perhaps, pliocene tin ore deposits of Billiton there occur peculiar rounded glass balls with grooved surfaces; they are also found, though very rarely, in certain quaternary tuff strata in Java and in the equally quaternary gold and platinum mines of South-eastern Borneo." The author classed these objects with the Bouteillenstein of Bohemia and the quaternary glass balls found in Australia. He believes that they cannot be of volcanic origin, because the nearest volcanoes are too far distant, and have, moreover, produced glassy rocks of quite a different nature. For various reasons they cannot be artificial either; he therefore takes them to be of non-terrestrial origin, and considered it probable that they are thrown out by lunar volcanoes during the quaternary and, perhaps, already during the pliocene period. The most recent paper on this subject, by Messrs. W. H. Twelvetrees and W. F. Petterd, was read before the Royal Society of Tasmania at Hobart in August last. Obsidianites have been found on both east and west sides of the island, as in the tin drift at Thomas' Plain and at Long Plain, near Waratah. The authors state that "the strange feature of the Tasmanian occurrence is that no glass of similar igneous rocks was known in the island, nor any trace whatever of tertiary or recent rhyolite or trachyte." They consider that they are unquestionably volcanic products, but think that the inference that the volcano was a lunar one was unnecessary, and was open to objection. The terrestrial volcanic hypothesis "only required that the molten spray should have been carried by winds as far as Tasmania and Australia."

Before considering these papers, it will be well to settle, as far as possible, the chemical nature of obsidianites, more especially as doubts have been expressed on this point, and to give a description of the various forms met with. As far as is known,

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1 Read before the Koninklijke Akademie van Wetenschappen, Amsterdam, 27th March, 1897. See also Jaarboek van het Mijnwezen, in Nederlandsch Oost-Indië, Amsterdam, pp. 235-272, pl. i., 1897.

only two complete analyses appear to have been made, viz., Nos. 1 and 2 of the following list :—

	No. 1.	No. 2.	No. 3.	No. 4.
Silica - - -	73·70	64·68	71·38	73·40
Ferrous Oxide -		1·01	} 19·36	} 4·74
Ferric Oxide - -	6·08	6·57		
Alumina - -	4·99	16·80		12·65
Manganese Oxide -		·20		present
Lime - - -	4·20	3·88	2·86	4·30
Magnesia - -	·10	2·50	1·89	·74
Soda - - -	5·20	trace		
Potash - - -	4·83	4·01		
Loss by ignition -	·55			
Total - -	99.65	99·65	95·49	95·83
Specific Gravity	2·47		2·44	2·47

No. 1. Analysis of a Wimmera specimen made by the late J. Cosmo Newbery, and published in the Melbourne Exhibition Catalogue, 1866.

No. 2. Analysis of a specimen from Uralla, N.S.W., made last year by Mr. J. C. H. Mingaye, and forwarded to me by the courtesy of Mr. E. F. Pittman, Government Geologist of that colony.

No. 3. Partial analysis of a specimen from Mount Elephant, made by Mr. F. Stone, Assayer to the Mines Department.

No. 4. Partial analysis made by the author of a specimen from Central Australia, collected by Professor Spencer.

The silica percentages shown by these analyses should prove indisputably their acid nature; even No. 2, with its lower silica contents, makes it an undoubted glassy representative of the trachyte series. The term acid is now used, not perhaps in its generally accepted sense, but only in contra-distinction to basic, which includes eruptives carrying up to about 55 per cent. silica. As a matter of fact, it seems probable that a number of specimens belong to the intermediate series. Mr. George W. Card, Curator of the Geological Museum, Sydney, has pointed

out that, while the low percentage of silica in No. 2 brings it within the intermediate group, there is a total absence of soda, which is certainly unusual, considering that the felspars of that group are of the soda-lime type. It is to be regretted that so little has been done in their chemical examination, because it is quite possible that each occurrence may present features in common, while differing from those of others. We should also be able to ascertain whether any divergence from ordinary obsidian can be established. Tested for fusibility, the edges and corners of the fragments became rounded, and in thin splinters a light-coloured glass was obtained, whereas basic glasses fuse readily to a dark opaque glass. The range observed in the specific gravity, although mostly inclining towards rhyolite, is still high for rhyolite-glass, and is more consistent with a trachyte or andesite glass, but the maximum obtained by Clarke is undoubtedly that of a basic glass.

He found them to vary from 2·42–2·7, Stelzner from 2·41–2·52, Twelvetrees and Petterd from 2·45–2·47; and from a number of specimens from different parts of the colonies I obtained from 2·42–2·48. All these experiments were evidently made on whole or fragmentary samples, so that, in some instances, the presence of gas vesicles may have slightly influenced the result. Microscopic examination proved it to be a pure glass, with at times scattered vesicles, but no microliths were observed. Vertical and horizontal sections cut from a button specimen revealed, even without aid of the microscope, a peculiar structure. It consists of a number of cloudy, narrow, more or less contorted bands at places closely intermingling. Mr. A. W. Howitt, who was good enough to examine these slides for me, says that under crossed nicols they slightly admitted light, and may therefore be due to strain. Mr. E. G. Hogg expressed the same opinion. Messrs. Twelvetrees and Petterd also observed this structure, and attribute the same cause to it. If it really represents the presence of internal strain, it must have been produced by rapid cooling, but obsidianites certainly do not exhibit any unusual degree of brittleness; in fact, rather the reverse for substances of their nature. It is open to question whether this is a natural structure or an artificial one produced in the preparation of the section; some of it is undoubtedly due to the latter cause.

Some confusion has existed in the part between the occurrence of obsidian and tachylyte in Victoria, and in some of the mineral catalogues localities are given for the former when it should unquestionably have been the latter. In the 1866 catalogue already referred to, two other analyses are given of obsidian from near Geelong, which show respectively 72·23 and 68·45 per cent. silica. Professor Ulrich informs me that Daintree also analysed some volcanic glasses from that neighbourhood and found them to vary in silica from 50 to 70 per cent. As natural glasses are only forms of lava which have cooled rapidly, they must in composition be identical with the devitrified or crystallised forms with which they are associated, and from the amount of silica shown by their analyses we would at least expect to find trachyte in that part, but instead of this being so it is stated that they occur in a basalt quarry in patches and irregular veins of an inch or more in thickness, of generally a black to brown, sometimes a bluish-grey colour. The specimens marked 24 and 24*a* are in the National Museum Collection of Victorian Minerals, and it is from a portion of these that the analyses were made. No. 24 is opaque and of a dark grey colour. It contains peculiar spherules of a devitrified vesicular character, the glass itself being quite homogeneous and free from vesicles. It is readily fusible to a rather frothy glass. By analysis I obtained 53·2 per cent. of silica, and this, with its easy fusibility and other characteristics, should place it within the tachylyte group. Mr. O. R. Rule informs me that there was only a small quantity of this variety found, although he had spent much time in search of it. I think I might therefore be justified in saying that, so far as we know at the present time, with the exception of obsidianites, acid volcanic glass, or obsidian, does not exist in Victoria.

Obsidianites may be briefly described as small bodies of dense obsidian, of regular but varying form, which are found in alluvial drifts and scattered over various parts of Australia and Tasmania. The largest I have seen of the spherical ones measures 59 mm. in its greatest diameter, and of those with an elongated form, one in the Warrnambool Museum measures 90 mm. in length. They are, however, mostly of a smaller size. The most characteristic form is that bearing a marked resemblance to

a button, a fact to which the term, "obsidian button," frequently applied to them, is due. This obsidianite may be said to consist of a flattened spherical centre surrounded by a marginal rim, which on the one side forms the continuation of the spherical surface, and when viewed from that side, as a rule, no indication of it is seen. This side shows generally a number of successive circular flat grooves, sometimes forming a distinct spiral. The other side exhibits the rim surrounding the central portion, which is always more or less pitted. These pittings, which are usually scarce on the rim and under side, are small and frequently of perfect hemispherical shape. The rim is sometimes quite smooth and regular on the outer edge, forming a complete ring, or else broken and irregular, but it always shows a depression or trough all round. With two exceptions, for one of which see Pl. III., Fig. 8, this is the only form observed with this rim. Most of the others are round (Figs. 4 and 5, Pl. III.), oval or elongated (Figs. 1 and 2, Pl. III.) in general form, the latter ones being contracted in the centre, at times roughly resembling a dumb-bell. The top and bottom are more or less convex, the bottom, or smaller section, being always of greater convexity than the top. They are both pitted to a greater or lesser extent, sometimes like that in the specimen next described, or in a more regular manner. The sides are rudely corrugated or furrowed in an approximately vertical direction, and slope at various angles, but they can be traced in a series of specimens to gradually become merged into part of the lower convex surface, in which instance the obsidianite assumes the form of two hemispheres of unequal diameter joined together, and we have a more or less spherical body. The corrugations are then much less conspicuous and at times almost obliterated. The sides show fewer pittings than either top or bottom. Without doubt the most interesting form met with is that of the hollow obsidianites. The one from Kangaroo Island has been fully described by Stelzner, but no description appears to have been given of the Horsham specimen (Figs. 1 and 1A., Pl. IV.). This obsidianite, in its greatest diameter across the peripheral ridge, measures 59 mm., and at right angles to this, 52·5 mm. In shape it is approximately spherical, but it has the characteristic form just mentioned of two hemispheres of unequal diameters joined together. The

larger section is generally smooth and marked with pittings crowded into irregular bands or patches enclosing smooth elliptical centres. The smaller section shows the peculiar corrugations commencing immediately under the peripheral ridge, but gradually fading away as the centre of the section is approached. The pittings are also present, but to much lesser extent and more equally distributed. It also shows marks or short grooves, in their arrangement somewhat resembling Hebrew characters, commencing at a slightly raised centre and radiating in six irregular lines towards the ridge. These grooves are also noticed in other specimens. The smooth elliptical centres referred to above are also outlined by fine groovings in places passing through the pits. In some instances the pittings themselves have the appearance of being drawn out, forming short grooves parallel to the fine markings.

Another feature is that some of the pits are contained within others. The interior of the obsidianite, which is slightly egg-shaped, has its greater diameter of 47·5 mm. in the direction of the smaller outside diameter. The other inside diameter measures 44·5 mm. It is perfectly smooth and has a high polish The obsidian is quite dense, with the exception of a few scattered vesicles, and is of a brownish colour in transmitted light. One or two points in connection with this specimen are worthy of mention. In general external form it differs only in being rather more spherical than other solid specimens, and in this respect, to all intents and purposes, they may be regarded as identical. This being so, it is evident that the presence of the cavity cannot have had any influence of consequence upon its configuration. The vesicles contained in the wall are spherical and small and few in number. Had the obsidianite been produced from a fragment of lava rich in gaseous components, the walls would surely have been highly vesicular, with a tendency for the vesicles to be drawn out in a direction coincident with the surface.

A striking feature in this specimen is the remarkable difference shown between the two sections. They are sharply defined by the ridge, as if two diverse agencies were at work in their formation. With regard to an explanation for the production of the button-shaped, or in fact any, specimens it must to a great

extent be hypothetical, but what is now advanced is the result of the examination of numerous specimens from all parts. Of these, a number seemed to suggest a series in the development of button forms commencing with the elongated or round types. In the first case, if we assume on ascent or descent, as the case may be, of the plastic material during rapid horizontal rotation, the tendency will naturally be, in these elongated bodies, to cause the material to flow towards the ends by centrifugal force, and at the same time the resistance of the atmosphere might have the effect of pushing back the outside portion of the obsidian from the front or advancing side, and so producing the rim.

Should this action be continued further, the material will go on accumulating at the ends until the centre becomes so weakened and reduced that a separation takes place, resulting in the formation of two incomplete buttons, then if plasticity and flight are still retained, it is reasonable to infer that two complete forms will result. Finally, the rim will be pushed so far as to cause a complete separation between it and the ellipsoid centre (Fig. 9, Pl. III.), and, if conditions are still favourable, a new rim will be formed, and the operation repeated. These solid centres are not uncommon, but only two separated rims have come under my notice.

With the other type, the process would be simpler, comprising only a pushing back of the plastic material in order to form the rim, and give the characteristic button-shape. This is practically the same explanation as that offered by Professor Stelzner to account for the rims, and he compares it to the pushing on of a glove-finger or the form produced by firing a leaden bullet into sand. These forms might then be said to represent various stages in the production of the button obsidianites, and depends primarily upon the shape of the original fragment, upon the degree of plasticity, and, finally, upon the rate of ascent or descent and rapidity of rotation. That they all reached the earth's surface in a solid state seems apparent, because in no instance has any alteration from their symmetrical form been observed, and some modification would have resulted had they landed in a soft or plastic state. Professor Stelzner does not think the assumption of rotatory flight necessary for the production of form as suggested by Darwin, and he compares it to the causes which

induce the shape of a drop of water, or fluid lead descending from a tower or into a shaft, forming shot globules, but modified by the influence of atmospheric resistance. I have also assumed that rotation took place, simply because it seemed the most reasonable view to adopt on account of variance exhibited in some specimens, and that a simple progressive motion does not seem compatible with the elongated form with contracted centre. Even in the button-shaped obsidianite, the flat grooving shows at times a distinct spiral, as if it had been turned on a lathe, and in one specimen (Fig. 6, Pl. III.), the upper surface is scored with fine circular lines, or what is probably a fluxion structure due to rotation about a vertical axis. Other specimens have the pits on that surface arranged in a similar manner. I do not therefore think that the causes which induce the spherical form of what could have entirely prevailed, and certainly I have not seen any obsidianite bearing a resemblance to the form of a bomb which has, according to Professor Stelzner, had a simple progressive motion.

The pittings, which are so characteristic of obsidianites, afford interesting matter for investigation. If they were produced at the moment of their origin, before the present forms were attained, which we suppose to be due to their passage through the air whilst in a molten state, it might naturally be expected that they would have thereby suffered elongation and contortion. In the hollow specimen and some of the others to a certain extent, this seems to have taken place when an apparent flow of the material has elongated and drawn the pits into groups and bands so closely crowded as to almost blend into one another. Also on some of the button-shaped obsidianites on the smooth grooved surface no pitting appears, the conclusion being that they were smoothed out or obliterated by the friction of the air against the rapidly moving object. On the contrary, however, other specimens exhibit the pittings equally distributed over the surface, and show no indication whatever of alteration from the regular half sphere, and in one instance two isolated pits of undisturbed form are present on the rim of a most perfect button-shaped specimen. They look very much as if they were caused by some small spherical body falling on the soft material. It is also observed that the grouping which is present in the hollow speci-

men has been sharply limited by the peripheral ridge, and the pits on the corrugated portion are not affected in the same way. Besides this, the occurrence of pits within others suggests a doubt as to whether they were originated at one time. Again, in Fig. 6, Pl. III., the surface has the appearance of being completely covered with a black coating, as if it has been frosted, but on close examination it is seen to consist of innumerable pits, so closely aggregated as to present no perfect forms. This structure resembles on a small scale the pittings or thumb marks, so well known as characteristic of meteorites. It is more than likely, therefore, that these pits result from a cause acting throughout the time they were in a molten or, at least, a soft condition, even after their ultimate form was assumed, and that they were not due to decomposing agencies at a later period. The corrugations, which, as far as can be ascertained locally, bear a resemblance to the ridges and furrows of meteorites, are always present on the sides of obsidianites, and are approximately vertical in their direction. If they are due to a similar cause, that of a flow of the melted material from front to back, then they could not have been formed by a rapid descent or ascent. Had this been so, they would have been horizontal or otherwise; they would simply be rims, because this is practically how these are supposed to have been formed. It appears, therefore, under this assumption, that they resulted in all probability in a rapid horizontal rotation. Some of the button specimens have a slightly wrinkled appearance on the outside of the rim, as if it were indicative of previous corrugation, which has been partially overcome and modified by the friction due to vertical flight.

The markings on the obsidianites from Central Australia, which were kindly lent to me by Mr. J. A. Watt for examination, differ both in form and distribution from the pittings, and are probably due to a different cause. Their entire surface is completely scored with these small marks, and their general form shows signs of erosion, as mentioned by Messrs. Tate and Watt. The view that these surface markings are secondary is strengthened by the fact that some of the specimens have every appearance of being fractured either by their fall on earth or contact with other substances; but the fractured surface differs in no way from the remainder. If they are secondary, then a

cause will be found in the scouring action of the wind-blown sand, which no doubt exerts extensive corroding influences in those parts.

An important fact in connection with the occurrence of obsidianites is their wide distribution, and, if their origin is limited to one point of eruption, it will be evident that some most extraordinary agent must have been employed to spread them over so immense an area. An idea of this may be gained when it is realised that these objects have been reported at Albany in the west and Uralla in the east, or almost at the limits of the continent in those directions. In the north they are recorded from the McDonnell Ranges, and in the south they have been found in various parts of Tasmania. Within these limits their occurrence is reported from many parts. In West Australia, since the discovery of the goldfields, they appear to have been found plentifully scattered over the surface and in the alluvial of Coolgardie and surrounding districts. Victor Streich[1] says they have been collected at Mount Squires, the Fraser Range, in the sandhills of the Great Victorian Desert, and at the Birksgate Range.

According to Mr. H. Y. L. Brown, Government Geologist of South Australia, they occur similarly over the province, more especially in the far north, and Messrs. Tate and Watt found numerous specimens between the Stevenson River and Charlotte Waters. Professor Tate[2] mentions that he has seen a specimen obtained at Gawler, from the centre of a nodule of travertine; and several that were collected about Stuart's Creek, and one from King George's Sound. Pitchstone and obsidian bombs are said by Mr. J. Chandler,[3] of the Peake, to be plentiful on the plains, and Mr. Canham,[3] of Stuart's Creek, reports similar specimens. The hollow specimen described by Stelzner is said to have come from Kangaroo Island. Clarke's record[4] of their occurrence at the Wannon appears to have been the first in Victoria. In the south-west district of this Colony many have been found, as at Mounts Elephant and Eccles. They are

1 Trans. Royal Soc. S. Aust., vol. xvi. (1893), pp. 84, 94.

2 Trans. Philosoph. Soc. Adelaide, S. Aust., vol. ii. (1879), p. 70.

3 Trans. Roy. Soc. S. Aust., vol. iv. (1880-81), pp. 148, 149.

4 Quart. Journ. Geol. Soc., vol. xiii, 1857, p. 188.

also recorded[1] from a post-pliocene drift at Spring Creek, near Daylesford. Obsidian is said[2] to occur at Ararat and Retreat Creek, Ingleby, but no particulars are given. Specimens in the Warrnambool Museum are labelled from Mount Rouse, Grassmere, and from Mepunga two feet from the surface. Mr. R. G. Johns, of Ballarat, states that they have been found on the surface at Warrnambool, Balmoral, Harrow, and Edenhope, in the Western District; in the auriferous drift near Ararat sixteen feet from the surface, and at Rokewood thirty feet from the surface; also in the shallow workings of the Hard Hills, near Buninyong. He reports the discovery quite recently of an obsidian ring, which was found on bedrock sixteen feet from the surface, at Rocky Point, about eight miles from Ararat. Mr. T. S. Hart, of the Ballarat School of Mines, has kindly given me the following list of localities from which the specimens (all of the characteristic button shape) in their Museum were obtained: Telangatuk, north of Balmoral; Glenelg River; Nerring, near Beaufort, found in white clay twelve feet from the surface; Byaduk Creek, Hamilton; and Bolwarrah, Moorabool River. Mr. G. W. Card informs me that they occur at Uralla, N.S.W., in shallow leads and scattered over the surface, but that, although said to have been found in deep leads there, no proof of their so occurring could be obtained. They are also reported from Thackaringa, Tumbarumba, Cobar District, Majors Creek, (Braidwood), and Broken Hill. In that colony the specimen described by Darwin was found between the rivers Darling and Murray, and those mentioned by the Rev. W. Clarke from the washing-stuff of the Uralla, and one from the Turon River, where it is supposed to have come from a depth of thirty feet in the auriferous wash. One in the Technological Museum is said to have come from Mount Oxley. Mr. R. L. Jack, Government Geologist of Queensland, states that obsidian button-bombs have been reported from the Central (Rockhampton) District. In Messrs. Twelvetrees and Petterd's paper it is stated that they occur in the tin drifts of Thomas Plains (East Tasmania); at Long Plains, near Waratah, in an alluvial drift ten feet from

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[1] Melb. Intercol. Exh. Catalogue, 1866.
[2] Geol. Survey Progress Report, vol. iii. (1876), p. 286.

the surface; at Springfield in a bed of quartz wash six inches thick, overlaid by two feet of alluvium, the whole resting upon granite; in stanniferous drift at Norfolk Range; Camden Plain; Mount Barrow in auriferous wash; and at Lisle in auriferous wash. We have one in the Technological Museum labelled from Back Creek, and Clarke records one from Supply Rivulet, River Tamar. No doubt obsidianites have been found in many other parts of the colonies, and the foregoing is not by any means a complete list, but it is as complete as I can make it from records and personal information. It is however, I think, quite sufficient to convince us that they occur all over the continent, and that they are not restricted to any particular localities, also, owing to their undeniable similarity of form and physical characteristics, that they are invariably products of a like nature and have a common origin. The two theories put forward to account for the phenomena are:—First, that they are terrestrial volcanic products; second, that they are non-terrestrial products or aërolites. It is generally agreed that if of terrestrial origin they are primary volcanic products and are not due to concretionary action in either eruptive or sedimentary rocks. If non-terrestrial, then we can only conclude that they have been derived from celestial bodies which are almost, if not quite, identical with some of our volcanic rocks. To account for their widespread distribution under the first hypothesis various agents are suggested, and in order to deal with this point we will assume that they are products of that nature. Four explanations are offered to account for their distribution, viz.:—By rivers or creeks, by ice, by means of the aborigines, and by the agency of the wind.

Obsidianites occur both on the surface and in the alluvium, and therefore, to a certain extent, there may have been a distribution of water. With regard to the latter occurrence, I have not been able to obtain any authentic information as to the nature of these drifts, except that they are mostly shallow, and that the presence of obsidianites in deep leads, although reported, has not been verified. The specimens examined, which are said to come from the drifts, are not in any way water-worn, and Mr. George W. Card informs me that those found in the alluvial of the Uralla showed no signs of attrition, their preservation being perfect. It seems probable that this feature is really

responsible for their being found at all, for had they become rounded and water-worn they would have passed unnoticed amongst the material comprising the wash. Considering their brittle character[1] and the conditions prevailing in transport by water, those which have been so found could not have been transported any distance worthy of mention, and this is consistent with their occurrence in shallow alluvial (post-pliocene), which is generally comprised of comparatively unrolled material derived from the adjacent country. On the other hand, they could scarcely have survived the attrition suffered in the formation of the deep leads, and if they did they would easily escape observation. It is quite evident, therefore, that in this instance the distribution could at the best be only a comparatively limited one, and that they are mostly found at or near the place of original deposition.

Those occurring on the surface, with the exception of the Charlotte Waters specimens, are similarly free from any signs of attrition, and are mostly in a most perfect condition, although some exhibit slightly weathered surfaces.

Independent of this, all other features associated with water carriage are entirely wanting, so that rivers or creeks, either of the past or present, cannot have taken any important part in their distribution.

Icebergs as a distributing agent cannot be considered seriously, as the conditions which would have been assumed are quite out of the question. For instance, we should have to assume that the continent was entirely submerged, over which the icebergs with their loads drifted and there deposited them. We must then suppose that the continent was raised above the water, the surface features being much as they are now, and we must further give the icebergs a monopoly of carrying obsidianites only from their origin, which it has been suggested might be

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1 Mr. J. G. O. Tepper, who translated Stelzner's letter, in a footnote thereto points out, as an objection to volcanic origin, that all molten glasses, lava, slags, etc., if cooled comparatively rapidly in the form of small masses, exhibit great and, mostly, excessive brittleness, which is not the case in the comparatively very small Australian bombs. In fact, they could not have been preserved at all if assumed to have been carried great distances by currents of flowing water and subjected to attrition by violent contact with other rock fragments, if they had not been endowed with a very considerable degree of cohesiveness.

Mount Erebus and Mount Terror, although we have not the remotest idea that they exist there. This manner of distribution is advanced by Mr. Gavin Scoular.[1]

Darwin's suggestion that the specimen he examined may have been transported by the aborigines seems to have received a good deal of support as a general explanation, and in that particular instance the Rev. W. B. Clarke looks upon it as the most reasonable view. Professor Tate also supports this explanation, and submits the following documentary evidence of the value set upon obsidian bombs by the Australian black. A correspondent from Salt River, King George's Sound, states :—"The black stones are very rare and much prized by the natives, who believe the possessor bears almost a charmed life and is able also to cure sick people of any complaint they may be afflicted with, as also to bewitch their enemies, or anyone with whom they have a grievance, tormenting them with all kinds of diseases, and finally destroying life itself." Mr. Canham, of Stuart's Creek, writes :—"With the stones will be found one to which a strange story is attached. I was told by the native I had it from that it was taken out of the breast of a sick man by one of their 'koonkies' or doctors, who, however, did not succeed in saving the patient's life, as some other 'koonkie' of another tribe had a greater power than the one who took the stone out. The sick native I mention died here of disease of the lungs, and all the koonkies in the country could never have saved him." Professor Tate apparently does not think this mode of distribution altogether satisfactory, as he offers quite a different interpretation to account for the presence of obsidian bombs between the Stevenson River and Charlotte Waters.

Messrs. Twelvetrees and Petterd mention that they have been informed that in the Coolgardie district, West Australia, they are collected by the aborigines, and used as charms by pressing them on the part of the body which is suffering pain. Mr. Johns informs me that Mr. Archibald, late curator of the Warrnambool Museum, told him, but in rather vague terms, that they were carried by the blacks as amulets, and sometimes broken up to obtain splinters for barbing spears. Mr. Johns himself does not

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1 Trans. Philosoph. Soc. Adelaide, S.A., vol. ii. (1879), p. 68.

think that they were produced by natural agency, but the shape and superficial appearance suggest a mould in the ground, the sides being formed by slips of bark or wood, which produced the grooves. The plastic material, he supposes, was not poured but pressed into it by a saucer-shaped mould. It is strange, if they have been used by the aborigines as charms or ornaments and so distributed by them, that no authentic record is extant. We hear of them being in the possession of the natives, but I have not been fortunate enough to find anybody who has actually seen them in use. Professor Spencer tells me that he never saw them worn by the natives of Charlotte Waters, where they occur plentifully, and that no notice of them whatever was taken; and even if they were distributed in this way to some extent, it brings us no nearer to the discovery of the point or points of origin, upon which the proof of a terrestrial origin must necessarily depend. As a matter of fact, nowhere within the colonies has any eruptive point, however far distant, been proved to have produced objects of a similar nature from which the aborigines could have obtained them, and therefore they could only have found them scattered on the surface in the manner in which we know them to occur.

Twelvetrees and Petterd's hypothesis, that they might have been distributed by winds, although original, cannot be regarded as a satisfactory solution of the problem. That objects of their size and weight could have been carried by winds from their place of origin, which is assumed to be outside Australia, to their ultimate position is incredible. It is true that volcanic ash may be carried many hundreds, and even thousands, of miles from its place of origin, as was instanced in the last eruption of Krakatoa, in 1883; and in the western States there occur remnant beds of fine volcanic dust, such as must have originally covered many square miles of territory, but the sources from which they were derived are now wholly obscured. In this case, however, we are dealing with a totally different material.

Professor Bonney calculates that it would take from 4000 to 25,000 particles of volcanic dust from Cotopaxi to make up a grain in weight, and it will be well understood that if dust of this fineness reached the upper currents of the atmosphere, it would remain suspended for lengthy periods, and might be then

carried immense distances from its source. On the other hand, some of the obsidianites weigh an ounce and more, and heavier ejectamenta such as these would only be subject to a comparatively slight divergence from their original flight.

It is quite evident, from their manner of distribution, that considered as volcanic terrestrial products, obsidianites could not have originated from a single eruptive centre. Neither are we much enlightened by assuming that they were ejected from a number of volcanic points situated within a reasonable distance of the places in which they were found, because many of the occurrences are remote from the nearest points of possible eruption, and we cannot satisfactorily account for their transportation; and is it possible to believe that such extensive denudation took place as to remove all concomitants of a widespread volcanic outburst, and at the same time leave these objects, some of which are in a most perfect state, as the sole representatives. Naturally these small objects would have yielded much more rapidly to decomposing influences than the extensive contemporaneous lava flow, and therefore have been the first to disappear. At Mount Elephant and Mount Eccles in our colony we have them actually occurring within an extinct volcanic area, and it might be thought that they originated from these points. As far as is known all the most recently ejected lavas of this part are basic, and in several parts vesicular bombs abound, but they differ totally in every respect from obsidianites, which we have already seen are acid. Now, as far as experience goes, nowhere within that locality, or indeed within the colony, have acid lavas been found. Some of the obsidianites are quite perfect in every respect, showing not a trace of decomposition, and are found lying upon the basaltic lavas now undergoing decomposition, and which are the products of our most recent volcanoes. Making due allowance for their difference of composition, which enables obsidianites to resist the attacks of decomposition longer than the bombs of a basic nature, it would be strange, if they are contemporaneous, that they are so perfectly preserved. And to assume contemporaneity we must believe that basic lavas and acid bombs were ejected at one and the same time, a state of things most highly improbable. If they really owe their origin to an acidic volcanic outburst, and by some means unknown to us

they have been transported to where they are now found, it ought to follow that where we have had extensive volcanic activity of this nature we may reasonably expect products similar in all respects. The nearest occurrence of this kind is in the North Island of New Zealand, where obsidian is very common in the rhyolite series, and an abundance of pumice occurs, but Sir James Hector states that he has never seen obsidian bombs[1] there, and Professor Ulrich says he has never heard of any such button-shaped bombs as the Victorian ones being found in New Zealand. But in regions where basic flows have taken place, bombs occur similar to those of the same nature found here, which are always more or less vesicular.

This fact opens the question whether solid bombs, either acidic or basic, are ejected by volcanoes. In speaking of bombs, I refer particularly to true bombs or masses of lava which have assumed a more or less regular shape through their gyrations in the air whilst in a molten state. I say this advisedly, because not only blocks and fragments of solidified lava may be ejected, but also pieces of foreign rocks through which the pipe burst, and which may differ totally both in physical and lithological character from the ordinary products. In this respect then we have just seen that in New Zealand solid bombs are not known, and it is hardly likely that where such extensive volcanic activity has been displayed they would not have been noticed if they existed. Then, referring to Professor Stelzner's paper, in which he gives a number of analogies, the only ones which can be taken as undoubtedly composed of dense obsidian are the moldavites and the obsidian balls from Mount Patak.

But the strange feature in, anyway, the first instance is that their origin, like the obsidianites, is enveloped in obscurity.

With regard to the second instance, Beudant says that the form of the obsidian specimens presents itself everywhere, which indicates necessarily a like cause in all localities. These specimens were found at the foot of hills composed of pumice and trachyte conglomerates, the latter overlying the former. It is

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[1] Professor F. W. Hutton, under the heading of obsidian, mentions a black vitreous volcanic bomb, highly vesicular inside, with a thin cracked vitreous skin on the outside, from Mount Haroharo, Lake Rotoiti, Tauranga Co. Trans. Royal Soc. of N.S.W., vol. xxxiii., p. 23.

asserted they only occur on the surface, and have not been found within the conglomerates. Their source is not mentioned, so that it is not quite certain whether they have been established as true bombs.

Stelzner also describes an obsidian bomb from Mexico, given to him by Rosenbusch, which he compares with obsidianites, but does not think the resemblance of form very close. Unfortunately he gives no particulars of its occurrence or its internal structure, so that we are left in doubt on these points. Darwin, in comparing these objects with the bombs from Ascension Island, was evidently misled, from the examination of a perfect specimen, by the pittings, which bear a strong resemblance to external signs of vesicularity; and Clarke also mentions them as being similar. The hollow obsidianite can scarcely be called vesicular, as the wall, with the exception of a few isolated vesicles, is compact. The smooth, polished interior is sufficient evidence of this. Let us now view the operation by which bombs are originated, and see whether it favours a solid or vesicular character.

Professor Judd[1] gives a graphic description of the phenomena taking place in an active volcano vent, and I cannot do better than repeat it here. It is as follows:—"If we take a tall, narrow vessel and fill it with porridge, or some similar substance of imperfect fluidity, we shall be able, by placing it over a fire, to imitate very closely indeed the appearances presented in the crater of Stromboli. As the temperature of the mass rises, steam is generated within it, and in the efforts of this steam to escape the substance is set in violent motion. These movements of the mass are partly rotatory and partly vertical in their direction; as fresh steam is generated in the mass its surface is gradually raised, while an escape of the steam is immediately followed by a fall of the surface. Then an up and down movement of the liquid is maintained, but as the generation of steam goes on faster than it can escape through the viscid mass, there is a constant tendency in the latter to rise towards the mouth of the vessel. At last, as we know, if heat continues to be applied to the vessel, the fluid contents will be forced up to its edge, and a

1 Volcanoes: What they are and what they teach. 1885 ed., p. 20.

catastrophe will occur, the steam being suddenly and violently liberated from the bubbles formed on the surface of the mass, and a considerable quantity of the material forcibly expelled from the vessel."

Under these conditions the surface of the molten mass must then be constantly traversed by jets of escaping steam, until, as is pointed out, the steam which collects faster than it can be liberated in this manner, frees itself by an explosion of greater or less intensity, carrying with it fragments of the lava. Now this explosion takes place near the surface in the region of the lava, which must necessarily be permeated with steam and consequently in a vesicular condition; it is thereby broken up and partly ejected in the form of vesicular bombs, lapilli and dust. The steam imprisoned in the bombs, during their passage through the air, tends to expand, and they become more or less completely distended with bubbles. This action must be the same no matter what the nature of the lava may be, only that probably in the case of acid lavas the explosive action might be much more violent, owing to their greater viscosity permitting a larger quantity of steam to accumulate and become more highly heated before being expelled. This, then, may have had some influence upon the apparent scarcity of acid bombs; that is to say, the lava in this instance would not be sufficiently fluid, when ejected, to take any very regular form, and would appear more as fragmentary pumice. The difference in the liquidity is evidenced by the fact that basic lavas form much more extensive sheets, sometimes flowing to great distances from the vents, than do the acid lavas, which tend rather to accumulate round the points of eruption. From what has been said it will be seen that the origin of volcanic bombs is of such a character as to reasonably infer that they would mostly be of a vesicular nature, whether acid or basic, and the apparent absence of obsidian bombs in the North Island of New Zealand, and in fact of all solid bombs in that and this colony as well, strengthens the idea.

The forms presented by the obsidianites are so extraordinary and curious that they at once direct attention as being a most unusual natural occurrence. As far as I can gather, most of these forms have not an analogy amongst volcanic ejectamenta,

although approximated more by them than anything else known, and therefore this feature alone is of no avail in support of a terrestrial volcanic theory. Even Professor Stelzner admits this when describing the hollow specimen from Kangaroo Island, of which he says that an exact parallel case of such a natural glass is not known to him either from literary descriptions or from collections.

Darwin says that the obsidianite he examined seems to have been embedded in some reddish tufaceous matter. In one specimen from Mount Elephant which has come under my notice I also observed a material bearing a very similar character; but as it comes from a volcanic region, it may have gathered it when it fell, and there would be no special interest attached to its presence. Darwin's specimen, however, came from a part hundreds of miles distant from any known crater, and, if he is correct in his surmise, it certainly is a point in favour of a terrestrial volcanic origin. If this theory is a correct one, little evidence has as yet been brought forward to establish it; but their discovery over such an immense area, their remoteness in some instances from any points of eruption, and the absence of evidence in others that they are due to local volcanic outbursts, and, finally, the want of proof that they have been transported, are in themselves obstacles difficult to explain away by any such hypothesis.

We have now to consider the non-terrestrial or meteoric theory. In the first place, it at once affords a satisfactory explanation of their indiscriminate and widespread mode of occurrence, and for this alone deserves serious attention. Mr. Verbeek goes so far as to say that they may have been ejected from the moon during the quaternary or perhaps pliocene periods, but as this involves a discussion on the origin of meteorites, it would evidently be out of place to offer any remarks about it. Neither is it desirable that we should do so, as we are only concerned generally with a non-terrestrial origin.

Two objections may be urged against this theory, namely, their regular form and their composition, both being entirely different to that obtaining in known meteorites. How the shapes could have been assumed under conditions compatible with a meteoric origin is purely a matter of conjecture. It seems

highly probable that in substances of their composition the shapes would be produced after entry into the earth's atmosphere, and that they represent fragments of comparatively large bodies. The enormous sudden temperature which would be generated on impact with the atmosphere would be almost certain to cause the original body to burst, resulting, in all probability, in an almost complete shattering of the body, and also probably complete consumption of the greater portion of it. Under these conditions the astonishing thing is, if they are meteoric, that they should have reached the earth's surface at all. Whether these bodies were originally glassy we cannot surmise, because, as they have been molten throughout, they may have resulted from the melting and rapid cooling of crystallised masses. The supposition of a molten state is certainly an unusual one amongst meteorites, as they bear strong evidence of only having been molten to an insignificant thickness of their surface, although there are instances in which some meteoric stones, or aërolites, appear to have been heated throughout their mass to a high temperature.

If, after the bursting of the original body, the various fragments were in a plastic condition, the shapes might have been induced by the hurling of these fragments through the air in all directions with different degrees of velocity. The time it would take these objects to reach the earth's surface would be extremely small, perhaps only a few seconds, and it might be expected that they would then be in at least a soft state. If this were so it would surely show itself by a flattening or otherwise in altering the original symmetrical form, but, as previously mentioned, in those examined there is no appearance whatever that such is the case. We must then believe that they cooled down with great rapidity, an operation which would have produced an extreme brittleness in a glassy substance—so much so, that a fall on the earth would have completely shattered them. Contrary to this expectation, they exhibit even less brittleness than obsidian from lava flows, which exists in masses and under conditions much more favourable to a slower rate of cooling. Nevertheless, it is most likely that only those survived that fell under favourable conditions and that many others were destroyed on contact with the earth whether of cosmic or terrestrial origin. With regard to their

composition, we see that it differs entirely from that of all known aërolites, which are basic and represent the basalts, and more especially the ultrabasic rocks of our earth. But it cannot be said, on account of this, that acid meteorites do not exist, because it is only natural that the more meteorites approach terrestrial rocks in their lithological character and composition, the less likely they are to attract attention. This is supported by the fact that few aërolites are known that have not been seen to fall, whilst, on the contrary, only about nine metallic meteorites or siderites have authenticated origin, and their nature is only recognised by their great difference from our ordinary terrestrial rocks. Now, nine only represents a small proportion of the siderites found, and if we assume that the aërolites which have fallen, but have not been found, bear the same proportion to those found, they must exist in very much greater numbers and have been passed by unrecognised.

It seems probable that obsidianites are not all of the same age, for under similar conditions we find some perfectly fresh, with a black, lustrous exterior, and others again more or less dulled and showing signs of decomposition. Further, their presence in post-pliocene drifts as well as on the surface and their variance in composition tend to support this belief. And under a meteoric hypothesis this is only what might be expected, as non-terrestrial bodies are constantly falling on the earth, and have been doing so in the distant past. The strongest argument against this theory certainly seems to me to be their regular form, which is so completely opposed to all we know of meteorites. Why it should be attained in these and not in others of a different composition, although perhaps equally fusible, is indeed remarkable, but is it not possible that these objects only represent a portion of this interesting occurrence, and that their exceptional shapes are really responsible for their discovery. If, on the basaltic areas of the Western District, irregular fragments of obsidian were seen, they would most likely, if at all, only attract passing notice, and so probably elsewhere. Fragmentary rocks of any nature would convey nothing to the majority of people, and only some structural peculiarity would take their interest. A fact which lends some strength to this theory is the occurrence under very much the same condition of somewhat similar bodies elsewhere,

as the Moldavites or Bouteillenstein of Bohemia and the glass balls of Billiton described by Verbeek, who also includes these objects in the same category. Among more uncertain occurrence might be mentioned one described by Karl Emil Kluge.[1] Under the Bouteillenstein variety of obsidian he states that such green-bottle balls come from India. They are from two to two-and-a-half inches in diameter, and are as hard as quartz. In the interior are found cavities about the size of large peas. Whilst one of them was being sliced by a Paris lapidary, the half which was not secured burst with a hissing sound and a detonation that resembled the bursting of "Rupert's drops." The specimens described by Beudant from Mount Patko, on account of their close resemblance, might also be included provisionally.

Considered as meteorites, then, their extraordinary manner of distribution is at once satisfactorily explained, and their surface sculpture is also consistent with such an hypothesis, it not having been met with on any undoubted terrestrial rocks; but, beyond this, we have nothing but negative evidence in its favour, and unless an actual fall is observed, it is quite apparent that its advocacy must be almost entirely based upon such evidence. It is, therefore, important that all other possible explanations should be thoroughly investigated and exhausted. If this is done, and they are all dismissed as untenable, we should, I think, be justified in attributing a cosmic origin to them.

In conclusion, I have to thank Mr. T. S. Hall and others who have kindly rendered me assistance in the preparation of this paper.

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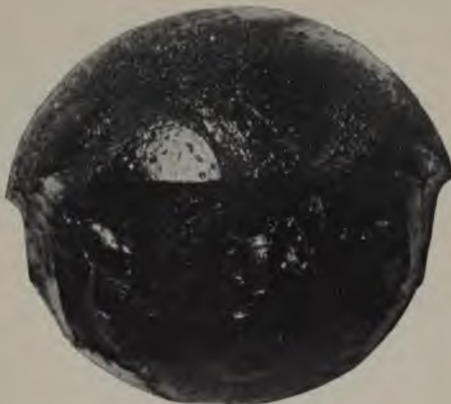

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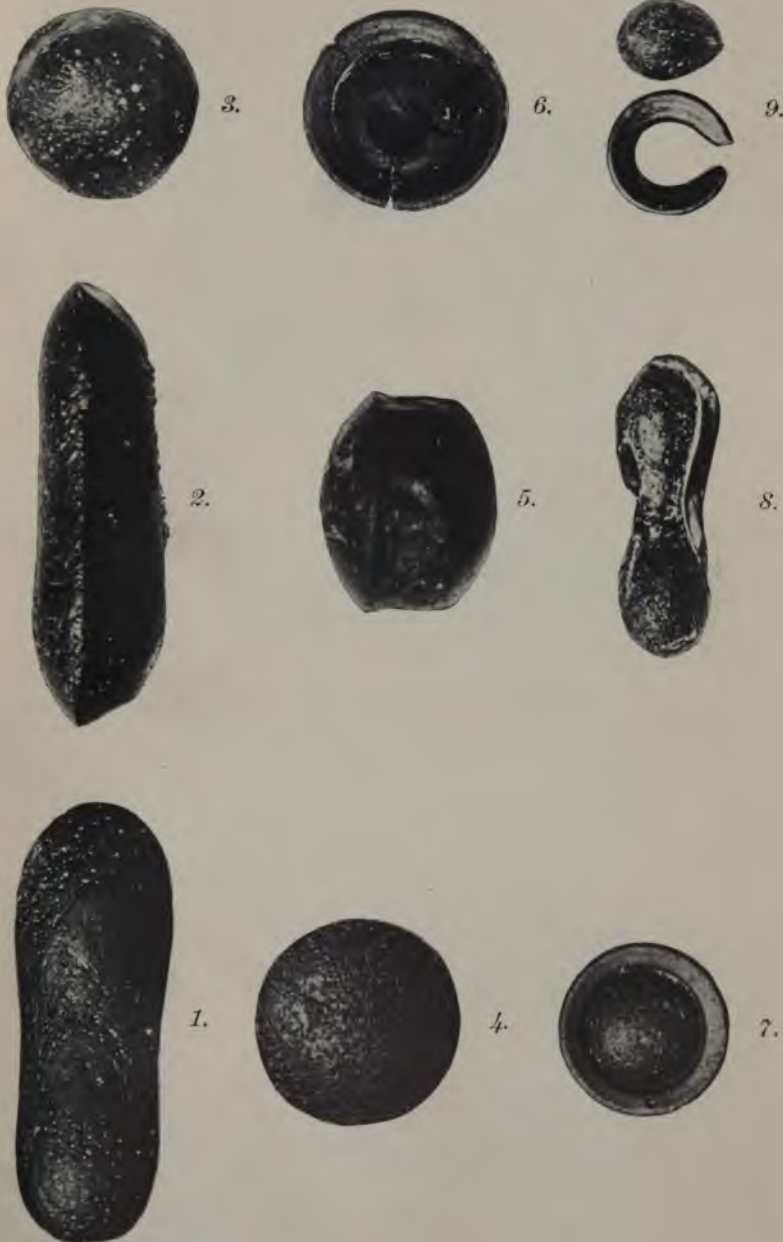
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DESCRIPTION OF PLATES.

PLATE I.

Fig. 1.—Elongated "obsidianite." Mount Elephant, Victoria. In the Industrial and Technological Museum Collection.

Fig. 2.—Side view of a specimen similar to Fig. 1. Albany, West Australia. In the Industrial and Technological Museum Collection.

Fig. 3.—"Obsidianite" of the spherical type. West Australia. In the Industrial and Technological Museum Collection. The reverse side is quite similar to that shown.

Fig. 4.—Side view of the spherical type. It differs from Fig. 3 in having a corrugated side. Locality not known. In the Industrial and Technological Museum Collection.

Fig. 5.—Top view of a specimen similar to Fig. 4, but more flattened. Mount Oxley, New South Wales. In the Industrial and Technological Museum Collection.

Fig. 6.—"Button-obsidianite," showing a cavity near the centre and three curious radial cracks. Lisle, Tasmania. In the Industrial and Technological Museum Collection.

Fig. 7.—"Button-obsidianite" of very perfect form. Charlotte Waters, Central Australia.

Fig. 8.—Unique specimen of the elongated type, with rim broken away in part. The under side is quite smooth and lustrous, and bears the flat grooving characteristic of the button type. Back Creek, Tasmania. In the Industrial and Technological Museum Collection.

Fig. 9.—Rim and solid ellipsoid centre which have become separated. Mount Elephant, Victoria. In the Industrial and Technological Museum Collection.

PLATE II.

Fig. 1.—Hollow "obsidianite." Upper Regions Station, Horsham, Victoria. In the National Museum Collection.

Fig. 1*a*.—Section of same, showing the cavity with a high polish.

Fig. 2.—Rim and solid centre (Fig. 9, Plate I.) combined.

Fig. 3.—Reverse view of Fig 7, Plate I.

Art. IV.—*The Geology of the Lower Leigh Valley.*

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AND

J. F. MULDER.

[Read 14th July, 1898.]

(With Plates V. and VI.).

The River Leigh, or Yarrowee as it is sometimes called, rises in the Dividing Range, and after a generally south course empties itself into the Barwon River at Inverleigh. Though only a moderate-sized stream, it has for many miles of its course cut a wide and deep gorge in the face of the country. In places, extensive flats are enclosed between the opposite banks, as, for example, that on which the small township of Shelford stands, and another near Dog Island, higher up the river.

We shall confine our description of the geological features of the gorge to the lower part of the river, namely, from Reid's Creek on the north to Inverleigh on the south. The country intersected by the river from Dog Island northwards to a point a little west of McQuinn's Creek was geologically surveyed, mapped, and reported upon by Messrs. Etheridge and Murray in 1867-8.[1] A small portion of the mapped area, viz., from Dog Island to Reid's Creek is remarked upon by us, as it includes an important eocene section. The actual boundary of the eocene is some distance beyond, but as, judging from the Survey's report, the few remaining outcrops are comparatively uninteresting, we did not visit them. Previous notices of the unmapped area to the south are, we believe, confined to two papers by ourselves, one on eocene and the other on miocene rocks in the vicinity of Shelford.[2] In the first of these a list of the fossil contents of the Red Bluff section was included, but the number of species known from that bed has since been much

1 Quarter-sheet 26 S.E. and Progress Report, No. II.

2 Geelong Naturalist, Sept., 1894; Trans. R. S. Vic., 1897.

increased. From the escarpments higher up the river many additional forms have also been collected. Moreover, some important revision work has been lately done by various palæo-conchologists, and a greatly extended, as well as revised, list of fossils is herein submitted.

Eocene Beds.

In discussing these, it will be most convenient to commence with that at the Red Bluff (Sec. II.), which is the best known and by far the richest of the fossiliferous outcrops on the river. As stated in our previous notice of it, the fossils on the exposed face adjoining the river show only for about 50 feet from the water's edge, but a rubbly decomposed limestone can be traced to a farther height of 100 feet; that is, within 40 feet of the level country at the top. On the northern face of the bluff the limestone is occasionally hard and compact, but fossils in it are exceedingly scarce. Much of the hill is masked by ironstone and basaltic boulders fallen from above—so much so, indeed, that on a cursory inspection one is apt to regard the basalt as a much thicker deposit than it really is. Above the limestone, at the spot where the section was measured, there is about 15 feet of ironstone conglomerate (miocene), which passes directly under the capping of basalt on the summit. The section is therefore—

Basalt	... ...	25 feet
Miocene conglomerate	... ...	15 „
Eocene	Rubbly limestone	100 „
	Fossiliferous clays	50 „
	Total ...	190 feet

Erosion of the eocene surface prior to the deposition of the miocene is evident enough, not only here, but in other sections to be quoted, and the younger rock has apparently filled in depressions in the older; thus, a few yards to the west of the measured section, miocene boulders were seen cropping out from ten to fifteen feet lower down the hill. On the other hand, where the junction of the miocene with the basalt is visible on the bluff, the latter rock rests horizontally upon the levelled off surface of the former.

On the opposite side of the river, and about two miles below the Red Bluff, there is an eocene outcrop, which we examined (Sec. I.). Here the fossils, which resemble those at Section II., are sparingly distributed in a clayey matrix. They cease at a height of 80 feet from the river, and are then succeeded by clays and sandy ironstone, mingled with quartz pebbles. No fossils were observed in the ironstone, but we have no hesitation in classing it as miocene. There is no capping of basalt above it, as this rock is absent from the east bank of the river from Golf Hill right on to Inverleigh. Amongst the fossiliferous clays of this section there is in places a deposit of powdery, cream-white carbonate of lime, which, if continuous down to any depth, might prove of commercial value.

We did not examine the eastern bank of the Leigh between here and Inverleigh, but at the latter place we observed a long stretch of eocene clays just above the water's edge, and the continuance of eocene strata all the way is therefore assumed. As we drove along the western bank from Inverleigh to the Red Bluff, several outcrops of limestone were noticed; and in one place, where a dam had been excavated, the same rock, much decomposed, showed below the alluvium of the flat. Eocene limestone also crops out occasionally, both at the level of the road and at a considerable elevation on the bank between the Red Bluff and Shelford. There is, however, no more clay, and though fossils are certainly obtainable by patient searching, they can rarely be extracted whole. The relations of these limestones to the accompanying basalt and overlying miocenes are very interesting; but their discussion must be postponed till the remaining eocene sections have been described.

The next notable outcrop is just over the Shelford Bridge, on the east side of the river (Sec. V.), where the incline leading to the table-land on the summit of the bank has been cut down in making the road, and the steep face thus formed has exposed the eocene strata for a distance of about 100 yards. They consist of calcareous clays, with thin bands of limestone running through them. Observations of the dip of these bands were made, with the following results. At the first station, close to the commencement of the cutting, an apparent dip of 4° to east 5° north, was recorded. At the second station, 30 yards up the hill, and

also at the third station, 50 yards higher up still, the bands run horizontally due east and west. There is thus a change of direction in the face of the cutting amounting to about 5° between the first and the succeeding stations. At the same time the dip changes abruptly from 4° to 0°. Either there is current bedding for a short distance, or, as is more likely, by a slight change in the direction of the cutting at the first station, the true dip from the hill, *i.e.*, towards the north, is indicated. The rocks are too rough and crumbly to admit of very exact measurements.

Fossils are not only very scarce in the section, but they are also so rotten, that in an hour's search only a few fragments were obtained. Amongst them we recognised the following :—

Dimya dissimilis	Cidaris spp. (spines)
Ostrea hyotis	Cellepora fossa
Terebratula sp.	Lunulites rutella

and other species of polyzoa.

The organisms were traced up to an elevation of 150 feet above the water's edge, but unfossiliferous limestone was found for 30 feet higher. Above the limestone, ironstone boulders occur and continue to the hill-top. These again we class as miocene.

It may be conveniently mentioned here that the river level at Shelford Bridge is the datum line, to which reference is occasionally made in this paper. Its height above sea level is not precisely known, but from aneroid readings, with Leigh Road Railway Station for the starting point, we estimate it as between 220 and 250 feet.

In following up the river from the bridge through Golf Hill pre-emptive block, the eocene is practically concealed beneath later deposits, but that it is still present is proved by the nodules of limestone thrown out of rabbit burrows, or from holes dug by the station people. Higher up, the banks are steeper than in the neighbourhood of Golf Hill, and several fine sections of the eocene are exposed. The most prominent of them is on the eastern bank, immediately south of a small island, locally known as Bull Island, which is formed by a short billabong in the course of the river. Perhaps the prettiest scenery in the Lower Leigh Valley is to be found here. The fossil banks form an amphi-

theatre surrounding an extensive flat, through which the stream pursues a very tortuous course. Close at hand is the basalt capped hill called Dog Island, while in the distance the narrow gorge of the Dog Rocks bounds the view. The name Dog Island, commonly applied to the hill just mentioned, is quite inappropriate, as it is not really an island at all, the river flowing on its west and south sides only; on the north and east, the land, though slightly depressed, is still much above the river, which, we are assured, never inundates it, even in the highest floods.

Further remarks to be made upon the rocks of Dog Island are postponed till the principal eocene sections in the vicinity have been described.

At the Amphitheatre or Bull Island section (No. X.), the strata exposed on the bank are:—

Ironstone drift	40 feet
Limestone, masked by reddish clay ...	50 „
Banded limestone, with eocene fossils ...	40 „
Marls, yielding an abundance of fossils, with blocks of hard limestone	90 „
River alluvium	20 „
Total height of bank ...	240 feet

In the marls are disseminated small quartz pebbles, while fragments of ironstone, no doubt derived from above, occur on their surface.

The water level at the foot of the bank is 80 feet above our datum line, and the upper bands of limestone here thus reach a greater elevation than similar rocks at the top of the eocene in the Shelford Bridge and Red Bluff sections. So also the gastropod bed at the base of the Red Bluff is lower than the marls of Bull Island. It is probable that these marls do not extend far below the surface, as silurian rocks crop out in the river bed a few chains to the north.

Nearly all the fossils quoted in our list were obtained from the amphitheatre and Red Bluff sections, which may be taken as respectively typical of the deposits to the north and south of Shelford. It is apparent that, though largely similar in both,

they are not entirely so. Being a previously unexplored bed, the majority of the new species recorded are, as might be expected, from the amphitheatre marls; in addition, these yield some which, so far, have not occurred in our gatherings at the Bluff, though they are known from more distant eocene deposits, as Belmont, Curlewis, Birregurra, Spring Creek, etc. We have thought it advisable to indicate the species which are special to either of the two sets of beds mentioned. This information is supplied more for the sake of future reference than for any immediate use we propose to make of it.

On the Bull Island section the fossils occur either loose on the surface or slightly adherent to the marly matrix. Many of the smaller species were obtained by sifting and washing the finer and more calcareous material.

Speaking of this and similar beds near at hand, Mr. Wilkinson, who surveyed the area many years ago, says: "These clays abound in well-preserved fossils. The surface of the out-cropping beds often glitters with the white shells which have been exposed by atmospheric action." When first seen by us this description was still correct. Fossils have now, however, become very scarce; and since none can be got by digging, future collectors must wait for a fresh crop to weather out.

There are occasional bands of limestone in the marls themselves, but above them the strata are composed of the former rock only, arranged in a series of horizontal shelves, which show for a long distance on the river banks. The limestone is a hard, solid rock, and contains very few recognisable fossils, but these few are also common in the clays. It took an hour's searching to obtain the following:—

Ostrea hyotis ?	Lovenia forbesii
Waldheimia garibaldiana	Lepralia edax
Waldheimia sp.	Salenaria sp.

and some indeterminable fragments.

Though the marls and limestones are lithologically so different, we yet regard them as palæontologically inseparable. We are led to take this view, not so much from a comparison of the few fossils collected in the upper strata with the rich fauna of the lower as from observations made at the next section (No. IX.), about a mile down the river and close to the southern boundary

of Henderson's Flat. Horizontal bands of limestone were noticed, as we crossed this flat, high up on the bank, and it was at first taken for granted that they continued up to the ironstone covering; but a closer examination showed that above these were clays, with well-preserved molluscan and coral forms similar to those at the amphitheatre. Fossils were gathered up to a height of 150 feet above the river, and the clay deposit is thus about on a level with the upper limestones, or 40 feet higher than the marls in Sec. X. There are about 20 feet of clays, and below them succeed limestones almost to the level of the alluvial flat. Change in the sediments, or, more probably, infiltration and subsequent consolidation of the material, may account for the limestone bands amongst the fossiliferous marls and clays of these sections.

Allusion has been made to the horizontal disposition of the strata at one or two sections. This is very clearly seen on the banks of Henderson's Flat at Sec. IX., and thence on to a little beyond Sec. X. In the latter locality, the amphitheatre encloses an angle of about 100 degrees, and on both of its sides the limestone bands, as tested by the clinometer, appeared horizontal; the observations were made on the summit of Dog Island, from which a good view of the amphitheatre is obtained.

At the two outcrops last described basaltic rocks are entirely wanting. It is important to note this, because just below Henderson's Flat, and thus quite close at hand, there is, at a comparatively low level on both sides of the river banks, a fringe of basalt, which has passed over eocene strata in two small exposures, one on the east and the other on the west side of the stream. This flow can be traced for some miles, and is quite distinct from the elevated and more extensive one which covers the table-land on the summit of the western bank. The lower and much older flow, for such it really is, shows only for a short distance on the eastern margin of the river, and thus, we think, never invaded the marls and limestones of Sections IX. and X.

This interesting lower flow will be discussed more fully later on; just now the sediments covered by it in the two sections mentioned are briefly noted.

In that on the eastern bank (Sec. VIII.), where the gorge of the river narrows at the termination of Henderson's Flat, a

massive limestone crops out about 12 feet from the water's edge. Both above and below there is clayey material containing the usual fossils. In the limestone itself the fossils are scarce, but they include only forms common to the clays. At a height of 100 feet the eocene is overlain by the lower basalt, which continues for the next 30 feet, when ironstone nodules of supposed miocene age succeed. The rocky basaltic promontory close to this outcrop is locally known as Point Henry; it forms really the eastern boundary of the lower flow, since, as we have seen, there is no sign of basalt from the base to the summit of the adjoining section on the east (No. IX.). At Sec. VII., nearly opposite on the western bank, the fossiliferous beds appear at the margin of the stream. Their junction with the overlying basalt is masked by soil, but a few boulders of the latter rock were noticed at a height of 150 feet. Fossils are abundant, though generally very fragile. Still, a few good shells were obtained here, and, by washing the fine calcareous material, many examples of the minuter species were added to our collection. The bed belongs to the type of the marls of the amphitheatre, and contains the same species. A few chains to the south, but about 60 feet up the bank, we observed an outcrop of limestone rocks in a gully running back from the river. Amongst some others, we noticed the following common fossils in this limestone:—

Bullinella aratula	Nuculana vagans
Amussium zitelli	Meretrix eburnea

We traced this gully up almost to the basalt-covered table-land at the summit of the bank, and noted the following out-cropping strata:—

Newer basalt	40 feet
Ironstone, probably miocene (no fossils observed)	30 „
Limestone, with *Cellepora fossa* ...	40 „
Lower basalt	50 „
Limestone, partly masked by alluvium	100 „
Total height of bank	260 feet

We were unable to determine whether the upper layer of limestone actually rested on the lower basalt; if so, the latter would, of course, be an intercalated flow. Probably, however, it is simply banked up against eocene strata which are connected beneath with the main mass.

There are several other exposures of the eocene on the western bank in the vicinity of the four sections just described, in which, for the most part, the lower basalt is the immediately overlying rock. Just south of Dog Island, however, and on the opposite or western side of the river, a mass of basalt, 25 feet thick and only 35 feet at its base above the water, appeared to us to be banked up against a limestone hill.

The following section across the river from Bull Island, and thus opposite the amphitheatre, was also observed :—

Limestone	10 feet
Lower basalt	50 „
Limestone, with fossils	25 „
River alluvium	5 „
	90 feet

A few yards to the south, however, the lower basalt crops out again at a height of 100 feet. We read this to mean that the basalt flowed *round* a mound of limestone and *over* the main mass.

On the west of the river there are one or two extensive gullies which are worth examination. We had only time to pay a hurried visit to one of them, which, on account of its rugged nature, we call Rocky Gully. This starts exactly opposite Point Henry, and runs in a northerly direction for about a mile and a half, until it terminates at the level of the upper basalt. Near its head, marls and limestones, the former showing the usual fossils, crop out just under the basalt, a thin layer of miocene only intervening. Down the centre of the gully there is a narrow water-way, thickly strewn with a confused mass of basaltic boulders, often of large size, mingled with occasional blocks of limestone. All of these have probably fallen from above, as at the head of the gully only was any basalt *in situ* noticed. We propose to examine this gully more closely on a future occasion.

The remaining eocene sections noted on the accompanying map of the Leigh River are to the north of Dog Island, and in the surveyed area. As pointed out by Mr. Wilkinson, they are of a different character to the beds which have just been described. On proceeding northwards from the amphitheatre, the horizontal bands of limestone, which there stand out so prominently on the face of the escarpment, soon disappear, being afterwards masked either by basalt or a covering of surface soil. From the neighbourhood of Dog Island there is a lava flow at the summit of the eastern as well as of the western bank, and by the Survey these flows are considered to originate from separate vents. At one spot, between Dog Island and the so-called Dog Rocks, there is a bold bluff of basalt, and below it limestone, apparently unfossiliferous, resting upon ordovician slates, which now become a conspicuous feature in the river-bed, and also for some distance up the banks on either side. A section in this neighbourhood is quoted by the Survey as showing the following succession of rocks :—

Vesicular basalt.
Soft yellow coralline limestone.
Thin bedded silurian sandstone.

The section we examined (No. XI.) is at the Dog Rocks, close to a deep pool of water, which bars further progress along the base of the escarpment on the eastern bank. Its position is approximately marked upon the map. The rocks there displayed are :—

Basalt	60 feet
Polyzoal limestone	55 „
Almost vertical ordovician	125 „
Total height of bank	240 feet

Concerning the coralline limestone or, as it is more correctly termed, "polyzoal limestone," near the mouth of Reid's Creek and in a few other places, Mr. Wilkinson says: "These upper beds consist of a soft yellow limestone, composed of an aggregate of fragments of polyzoa, corals, spines of echinoderms, and a few shells, chiefly terebratula, ostrea, pecten, etc. So broken are these fossils that one is rarely found perfect. The limestone is

sometimes very sandy, but generally it is wholly composed of a mixed mass of comminuted fragments of polyzoa."

At the Dog Rocks section the limestone is inaccessible, except at its highest portion, and slopes away from the nearly vertical silurian strata. We examined its contents by means of the blocks which have fallen down from above on to the silurian floor of the river-bed. It is, as Mr. Wilkinson says, crowded with polyzoa, but the determinable molluscan remains are very few, and the rock is so hard that we could only break out fragments of the fossils showing on the surface of the blocks. Amongst them we determined:—

Spondylus pseudoradula	Pecten polymorphoides
Ostrea sp.	Pecten sp.
Pseudamussium hochstetteri ?	Terebratula sp.
Pecten subbifrons	Cidaris sp. (spines)

In the quotation from Mr. Wilkinson just given, he alludes to these limestones as "Upper," and distinguishes them from the clays with gastropods, etc., which he terms "Middle" Miocene (Eocene). Certainly the polyzoal limestone of the Dog Rocks is at a higher level than the clays, etc., of the amphitheatre. According to our measurements, a horizontal line carried from the base of the polyzoal strata in the former section would just cut the top of the horizontal banded limestone in the latter. Apparently the polyzoal strata are also horizontally disposed, but the section is a short one, and a slight dip in some direction may possibly exist. Probably, therefore, in terming such beds the "Upper," and those of the amphitheatre the "Middle," Mr. Wilkinson only intended to convey the idea of superposition for the polyzoal rocks, and not to assert that any marked difference of geological age existed between the two sets of strata. In reference to this question of superposition for the strata under consideration, we simply remark that no actual contact of the polyzoal rock with the marls and limestones of the amphitheatre type was observed by us at any section on the river; and, in the absence of such contact, we cannot venture to pronounce on the actual sequence of the beds. Palæontologically, we hold them to be inseparable, basing our opinion, as far as the polyzoal rock is concerned, not merely on the few

fossils derived from the Dog Rocks section, but upon experience of similar strata in other localities. According to the Survey, there is an outcrop of the so-called Middle Miocene (Eocene) about two and a half miles farther up the river, but as no fossils are mentioned, we did not consider that there was sufficient encouragement to search for it.

We have now reviewed the principal eocene sections on the Leigh. The number of fossil species collected from them amount to 447, which are tabulated as follows :—

Pisces	... ...	1
Mollusca	Gastropoda	316
	Scaphopoda	5
	Lamellibranchiata	82
	Palliobranchiata	6
Echinodermata	... ...	4
Actinozoa	... ...	33

The Polyzoa and Foraminifera are not included in our enumeration.

The only recent species of Mollusca recognised are :—

Hipponyx antiquatus	Ostrea hyotis
Crepidula unguiformis	Axinæa laticostata
Dentalium lacteum	Limopsis belcheri

Saxicava arctica ?

and the proportion of living to extinct forms is therefore 1·7 per cent.

For Muddy Creek and Spring Creek, the distribution is fully given in our list; for other localities only occasionally.

Fossils collected only from sections south of Shelford are denoted by an asterisk, and from those to the north only by a dagger; in a few cases there is some uncertainty concerning this special record, and a query is then prefixed When no sign appears before the name of a fossil it is common to both the north and south sections.

For the identifications of many of the species listed we have consulted Professor Tate, who most willingly placed his wide knowledge of tertiary mollusca at our service.

List of Eocene Fossils.

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Pisces.			
†Lamna sp.			
Gastropoda.			
*Actæon olivellaeformis, Tate	x	x	
*Semiactaeon microplocus, Cossmann	x		Mornington.
Scaphander tenuis, Harris	x		Mornington.
*Scaphander admirandus, Tate *m.s.*			Mornington.
Bullinella aratula, Cossmann	x		Cape Otway.
*Bullinella infundibulata, Cossmann	x	x	
†Bullinella angustata, Tate and Cossmann	x	x	Adelaide.
*Bullinella cuneopsis, Cossmann	x		Bairnsdale.
*Bullinella phanerospira, Cossmann	x		Birregurra.
*Bullinella altíplica, Cossman			Mornington.
? Bullinella sp.			
Ringicula lactea, Johnston	x	x	Table Cape.
Ringicula tenuilirata, Cossmann		x	
†Umbraculum australe, Harris	x		Mornington.
*Terebra platyspira, Tate	x		
*Terebra additoides, T. Woods		x	Table Cape; *Miocene*, Muddy Creek.
Conus ligatus, Tate	x		

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
*Conus cuspidatus, Tate	x		
*Conus dennanti, Tate	x	x	
Conus heterospira, Tate	x		
†Conus pullulescens, T. Woods	x	x	
Bathytoma angustifrons, Tate	x		
Bathytoma sp., *aff. B. paracantha*	x	x	
†Surcula sp.		x	
†Surcula sp., *aff. S. johnstoni*			
Surcula sp.	x		Camperdown.
Pleurotoma murndaliana, T. Woods	x		
*Pleurotoma subconcava, Harris			Fyan's Ford.
Pleurotoma clarae, T. Woods	x		Cape Otway.
*Pleurotoma septemlirata, Harris (*Syn. P. trilirata, Harris*)	x	x	
Pleurotoma mulderi, Tate, *m.s.*			Cape Otway; Mornington.
*Pleurotoma, n. sp.			
*Pleurotoma, n. sp.			Curlewis.
*Asthenotoma consutilis, T. Woods	x	x	
*Asthenotoma, n. sp.			
*Asthenotoma, n. sp.			
Cordiera conospira, Tate	x		Table Cape.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
? Borsonia, n. sp.	x		
†Borsonia, n. sp.			
Drillia trevori, T. Woods	x		Mornington
Drillia integra, T. Woods	x	x	
*Drillia vixumbilicata, Harris	x		
Drillia sandleroides, T. Woods		x	Table Cape.
†Drillia, n. sp., *aff. D. trevori*			Moorabool.
*Drillia sp.	x		Gellibrand.
Drillia, n. sp.			Mornington.
*Drillia sp.	x		Mornington.
*Drillia sp.	x		
? Bela pulchra, Tate	x	x	
†Bela, n. sp.			Belmont.
Buchozia hemiothone, T. Woods	x		Curlewis.
†Buchozia cominelloides, Tate, *m.s.*		x	Belmont.
Buchozia sp. 1, *aff. B. cominelloides*	x		Gellibrand.
*Buchozia sp. 2, *aff. B. cominelloides*	x		
Buchozia sp.			Curlewis.
*Daphnobela gracillima, T. Woods	x	x	
†Daphnobela sp., *cf. D. recticostata*			
Clathurella bidens, T. Woods (*Syn. C. obdita, Harris*)	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
*Clathurella, n. sp.			
Clathurella sp.	x		
Clathurella sp.	x		Belmont.
Clathurella sp.	x	x	
*Clathurella sp.			
*Clathurella sp.			
†Clathurella, n. sp.			Curlewis.
*Cythara obsoleta, Harris	x		
Mitromorpha daphnelloides, T. Woods	x	x	
†Mangilia sp.	x		
*Mangilia sp	x		Moorabool.
Mangilia, n. sp.			
Mangilia sp.	x		Mornington.
*Mangilia sp.			Curlewis.
Mangilia sp.			
Cancellaria varicifera, T. Woods	x	x	
Cancellaria epidromiformis, Tate	x		
*Cancellaria platypleura, Tate	x		
*Cancellaria gradata, Tate	x		River Murray.
*Cancellaria exaltata, Tate			Mornington.
*Cancellaria capillata, Tate, *m.s.*	x		Curlewis.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Cancellaria, n. sp., *aff. C. wannonensis*			
†Cancellaria, n. sp., *aff. C. continua*			
†Cancellaria, n. sp.			
Olivella adelaidae, Tate	x	x	Adelaide.
Ancilla hebera, Hutton	x	x	
Ancilla pseudaustralis, Tate	x	x	
Ancilla cylindracea, Tate, *m.s.*		x	Table Cape.
†Ancilla orycta ? Tate		x	*Miocene*, Gippsland.
*Harpa lamellifera, Tate	x		
*Harpa sulcosa, Tate, *var.*	x		Camperdown.
Zemira praecursoria, Tate	x		Camperdown.
Zemira, n. sp.			Curlewis.
Volutilithes antiscalaris, McCoy	x		Curlewis.
*Voluta hannafordi, McCoy	x		
Voluta conoidea, Tate	x		
*Voluta strophodon, McCoy	x		
*Voluta weldii, T. Woods	x		Table Cape.
Voluta ancilloides, Tate	x		
*Voluta sarissa, Tate	x		Curlewis.
*Voluta polita, Tate	x		
†Voluta cathedralis, Tate	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Voluta allporti, Johnston (*Syns. V. pellita, J., V. halli, Pritch.*)		x	Table Cape.
*Voluta, n. sp., *aff. V. McCoyii*			Birregurra.
*Voluta, sp., *aff. V. sarissa*			
Lyria harpularia, Tate	x		
†Mitra dictua, T. Woods	x		Table Cape.
Mitra alokiza, T. Woods	x		
†Mitra atractoides, Tate	x	x	
*Uromitra mulderi, Tate, *m.s.*			
*Uromitra leptalea, Tate	x		Moorabool.
Uromitra biornata, Tate	x		
*Uromitra exilis, Tate	x		Moorabool.
†Uromitra clathurella, Tate	x		Belmont.
*Conomitra othone, T. Woods	x	x	
Conomitra ligata, Tate	x		Mornington.
Marginella inermis, Tate	x		Table Cape; Cape Otway.
Marginella propinqua, Tate	x	x	
Marginella micula, Tate	x	x	
Marginella wentworthi, T. Woods	x	x	
†Marginella subwentworthi, Tate, *m.s.*			Belmont; Curlewis.
*Marginella globiformis, Tate	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Marginella woodsii, Tate	x	x	
*Marginella inequidens, Tate, *m.s.*	x		
*Fasciolaria cristata, Tate	x		Mornington.
*Fasciolaria rugata, Tate	x		Mornington.
*Fasciolaria cryptoploca, Tate	x		Gellibrand.
Fasciolaria sp.	x		Belmont.
Columbarium acanthostephes, Tate	x	x	
*Columbarium foliaceus, Tate	x		Mornington.
Columbarium craspedotus, Tate	x		Mornington.
*Fusus senticosus, Tate	x		Mornington.
*Fusus, n sp., *aff. F. hexagonalis*			
†Fusus, n. sp.			Belmont; Curlewis.
Solutofusus carinatus, Pritchard	x		
*Latirofusus aciformis, Tate	x		Mornington.
Latirofusus exilis, Tate	x		Moorabool.
Latirofusus, n. sp.			
*Latirus succinctus, T. Woods	x		Moorabool.
Latirus belmontensis, Tate, *m.s.*			Belmont.
†Latirus, n. sp., *aff. L. linteus et L. tatei*			
*Latirus, n. sp.			Mornington.
*Latirus, n, sp.			

List of Eocene Fossils (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
*Euthria ino, T. Woods	x		Mornington.
†Euthria sp.			
*Tudicula sp.			Mornington.
†Leucozonia tumida, Tate	x		
*Leucozonia micronema, Tate			Mornington.
Siphonalia longirostris, Tate	x	x	
*Siphonalia styliformis, T. Woods	x		Curlewis.
†Siphonalia tatei, Cossmann, *var.*	x		Belmont.
†Siphonalia ischna, Tate	x		Gellibrand.
Siphonalia, n. sp.			Curlewis.
*Siphonalia, n. sp., *aff. S. styliformis*			
*Tritonofusus labrosus, Tate	x		
Cominella sp., *aff. C. fragilis*			
Phos variciferus, Tate	x		Mornington.
Nassa tatei, T. Woods	x	x	
Columbella crebricostata, T. Woods	x		Moorabool.
†Columbella, n. sp. 1, *aff. C. crebricostata*			Belmont.
*Columbella, n. sp. 2, *aff. C. crebricostata*	x		Gellibrand.
Columbella clathrata, Tate, *m.s.*	x		Curlewis.
*Columbella sp., *aff. C. clathrata*			
Columbella aciculata, Tate, *m.s.*	x		Mornington.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
*Columbella oryza, Tate, *m.s.*	x		Curlewis.
Columbella funiculata, T. Woods	x		Moorabool.
*Columbella cainozoica, T. Woods			Table Cape; *Miocene*, Muddy Creek.
*Columbella cingulata, Tate, *m.s.*	x		
*Columbella septemcostata, Tate, *m.s.*	x		
†Columbella, n. sp.			Curlewis.
†Columbella, n. sp.			
*Columbella, n. sp.			
*Murex lophoessus, Tate	x		Mornington.
*Murex camplytropis, Tate	x		Moorabool.
Murex rhysus, Tate	x		Mornington.
*Murex velificus, Tate	x	x	
Murex amblyceras, Tate	x		
*Murex asperulus, Tate	x	x	
Murex eyrei, T. Woods	x	x	
Murex polyphyllus, T. Woods	x	x	
*Murex sp., *aff. M. trochospira*			Curlewis.
*Murex, n. sp.	x		
Murex, n. sp.			
*Trophon ? n. sp.			
Typhis acanthopterus, Tate			Gellibrand.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Typhis maccoyii, T. Woods	x	x	
†Typhis evaricosus, Tate	x		Curlewis.
Typhis laciniatus, Tate	x	x	
*Typhis disjunctus, Tate	x		Mornington.
Lampusia tortirostris, Tate	x	x	
*Lampusia tumulosa, Tate	x		
*Lampusia protensa, Tate, *var.*	x		
*Lampusia gemmulata, Tate	x		Curlewis.
*Lampusia cyphus, Tate	x		Mornington.
*Lampusia woodsii, Tate	x		Gellibrand.
*Colubraria tenuicostata, T. Woods	x		Moorabool.
Apollo prattii, T. Woods	x		Mornington.
*Morio gradata, Tate	x		Gellibrand.
*Semicassis transenna, Tate, (*non S. sufflata, T. Woods*)	x		Mornington.
*Cypraea contusa, McCoy	x		Mornington.
*Cypraea eximia, G. B. Sowerby	x		Gellibrand.
*Cypraea leptorhyncha, McCoy	x	x	
Cypraea pyrulata, Tate	x		
Cypraea sub-pyrulata, Tate	x		Gellibrand.
Cypraea, n. sp., *aff. C. pyrulata*			

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Cypraea, n. sp., *aff. C. brachypyga*	x		Curlewis.
Trivia avellanoides, McCoy	x	x	
*Erato morningtonensis, Tate			Mornington.
Triforis wilkinsoni, Tate	x	x	
*Triforis sulcata, T. Woods	x	x	
Triforis planulata, T. Woods	x		Gellibrand.
†Triforis sp., *aff. T. planulata*			
*Triforis sp.			Corio Bay.
*Triforis, n. sp.		x	
†Triforis, n. sp.			Belmont.
Triforis, n. sp.	x		Curlewis.
Triforis sp.	x		
*Cerithium apheles, T. Woods	x		Mornington.
*Cerithium, n. sp.			Mornington.
†Cerithium, n. sp.			Curlewis; Birregurra.
*Colina exoptata, Tate, *m.s.*	x		
*Colina nodulosa, Tate, *m.s.*	x		Gellibrand.
*Colina, n. sp.	x		Fyan's Ford.
Newtoniella cribarioides, T. Woods	x	x	
*Newtoniella eusmilia, T. Woods	x		Bairnsdale ?
*Newtoniella lineata, Tate, *m.s.*	x		Moorabool.

List of Eocene Fossils (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Newtoniella accrescens, Tate, *m.s.*	x		Curlewis.
*Newtoniella sp., *aff. N. cribarioides*			
*Newtoniella sp.			
*Newtoniella sp.			Belmont.
*Newtoniella sp.			
*Newtoniella sp.			
Newtoniella sp.	x	x	Aldinga.
*Newtoniella sp., *aff. N. quinquelirata*			
*Trichotropis subquadrata, Tate	x		Cape Otway.
*Siliquaria occlusa, T. Woods	x	x	
†Thylacodes conohelix, T. Woods		x	Gellibrand.
Turritella murrayana, Tate	x	x	Table Cape.
*Turritella acricula, Tate			*Miocene*, Muddy Creek.
Turritella tristira, Tate			Table Cape; *Miocene*, Gippsland.
*Turritella septifraga, Tate		x	
Mathilda multilirata, Tate, *m.s.*			Gellibrand.
Mathilda transenna, T. Woods	x	x	
†Mathilda, n. sp.			
Mathilda, n. sp.			Curlewis.
? Isapis, n. sp.			
†Fossarus retrofactus, Tate			Table Cape.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
*Solarium acutum, T. Woods	x		Gellibrand.
*Solarium squamogranosum, Tate, *m.s.*	x		Gellibrand.
*Solarium, n. sp.			Moorabool.
*Heliacus serratus, Tate, *m.s.*			
Rissoia varians, Tate, *m.s.*		x	*Miocene*, Muddy Creek.
†Rissoia varicifera, T. Woods			Table Cape.
*Cheilutomia subvaricosa, Tate and Coss.	x		Fyan's Ford, etc.
†Hipponyx antiquatus, Linn.	x		
*Calyptraea undulata, Tate	x		River Murray.
†Crepidula unguiformis, Lam.	x		Table Cape.
*Xenophora tatei, Cossmann	x		
Natica polita, T. Woods	x	x	
Natica hamiltonensis, T. Woods	x	x	
*Natica arata ? Tate	x		
†Natica substolida, Tate	x		River Murray.
? Scalaria bulbulifera, Tate	x		
†Scalaria pleiophylla, Tate		x	Adelaide.
†Crosseia princeps, Tate	x		Adelaide.
*Eulima danae, T. Woods	x	x	
Eulima, n. sp.	x		Cape Otway.
†Eulima sp.	x		

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Eulima, n. sp. - - - -			*Miocene*, Muddy Creek.
*Eulima sp. - - - - -			*Miocene*, Muddy Creek.
Subularia johnstoni, Tate - - -	x	x	
Niso psila, T. Woods - - - -	x		Mornington.
†Eulimella, n. sp. - - - -			
Odontostomia victoriae, Tate, *m.s.* - -	x	x	
Odontostomia decurtata, Tate, *m.s.* - -	x		Camperdown.
*Odontostomia cingulata, Tate, *m.s.* - -			*Miocene*, Muddy Creek.
†Odontostomia sp. - - - -		x	
†Odontostomia sp. - - - -	x		Curlewis.
*Odontostomia sp. - - - -			
*Turbonilla cylindrica, Tate, *m.s.* - -	x		Moorabool.
†Turbonilla sp. - - - -			
†Pyramidella, n. sp. - - - -			
*Phasianella sp. - - - -	x		Lower Maud.
*Phasianella sp. - - - -			Moorabool.
†Collonia parvula, T. Woods - - -	x	x	
Leptothyra sp. - - - -			
Astralium aster, T. Woods - - -	x		Mornington.
†Astralium longispinum, Tate, *m.s.* - -		x	
†Cantharidus cavatus, Tate, *m.s.* - -	x		Gellibrand.

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Cantharidus sp.			Mornington.
†Cantharidus sp.			
†Cantharidus sp.			Bairnsdale.
†Trochocochlea ? sp.			
*Gibbula echinulata, Tate, *m.s.*		x	Gellibrand.
*Gibbula sp.			
†Gibbula sp.			Mornington.
? Gibbula sp.	x		
†Eumargarita sp., *aff. E. lucens*			
Solariella strigata, T. Woods	x	x	
*Calliostoma escharoides, Tate, *m.s.*	x	x	
*Calliostoma sp.	x		
†Calliostoma sp.			
*Calliostoma sp.			Moorabool.
†Calliostoma, n. sp.			
†Liotia roblini, Johnston	x	x	
†Liotia sp.			
†Liotia sp.			
? Cyclostrema bicarinata, Tate, *m.s.*			
Tinostoma calva, Tate, *m.s.*	x	x	
*Fissurellidea malleata, Tate	x		Gellibrand.

List of Eocene Fossils (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
? Fissurellidea, n. sp.			
† Fissurellidea, n. sp.			
Emarginula cymbium, Tate *m.s.*	x		Mornington.
*Emarginula wannonensis, Harris	x		Gellibrand.
*Emarginula, n. sp., *aff. E. wannonensis*			
Emarginula, n. sp.			Table Cape.
*Subemarginula occlusa, Tate	x		Gellibrand.
*Nacella ? sp.	x		
Scaphopoda.			
Dentalium mantelli, Zittel	x	x	
Dentalium subfissura, Tate	x	x	
Dentalium aratum, Tate	x	x	
*Dentalium lacteum, Deshayes	x		
† Dentalium annulatum, Tate	x	x	
Lamellibranchiata.			
*Ostrea hyotis, Linn.	x		River Murray.
*Gryphaea tarda, Hutton	x	x	
Dimya dissimilis, Tate	x	x	
Placunanomia sella, Tate	x	x	
*Spondylus pseudoradula, McCoy	x		Mornington.
Lima bassii, T. Woods	x		Mornington.

List of Eocene Fossils (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Limatula jeffreysiana, Tate	x	x	Table Cape.
Limea transenna, Tate	x		
Pecten foulcheri, T. Woods	x	x	
Pecten sturtianus, Tate	x	x	
*Pecten murrayanus, Tate	x	x	
*Pecten consobrinus, Tate		x	Aldinga.
†Pecten polymorphoides, Zittel	x		Gellibrand.
†Pecten subbifrons, Tate			Waurn Ponds.
Amussium zitteli, Hutton	x	x	
*Amussium, n. sp.			
Pseudamussium hochstetteri, Zittel		x	River Murray.
*Septifer fenestratus, Tate	x		Moorabool.
*Philobrya bernardi, Tate, *m.s.*	x		
Crenella singularis, Tate	x	x	
Crenella globularis, Tate	x	x	
Barbatia crustata, Tate	x		Gellibrand.
†Barbatia simulans, Tate	x	x	
†Barbatia consutilis, Tate	x		Gellibrand.
Barbatia pumila, Tate	x		Gellibrand.
Plagiarca cainozoica, Tate	x	x	
Axinaea laticostata, Q. and G.	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Axinaea cainozoica, T. Woods	x	x	
Limopsis belcheri, Ads. and Reeve	x	x	
Limopsis aurita, McCoy	x		Gellibrand.
Cucullaea corioensis, McCoy	x	x	
Nucula tenisoni, Pritchard	x	x	*Miocene*, Muddy Creek.
Nucula atkinsoni, Johnston	x	x	
Nucula morundiana, Tate	x	x	
Nucula, n. sp.			Birregurra.
Nuculana vagans, Tate	x		Gellibrand.
Nuculana apiculata, Tate	x	x	
Nuculana woodsii, Tate	x	x	
Nuculana obolella, Tate	x	x	
Nuculana huttoni, T. Woods	x	x	
Nuculana embolos, Tate, *m.s.*	x	x	
†Nuculana sp., *aff. N. woodsii*			
†Nuculana, n. sp.			
Trigonia tubulifera, Tate	x	x	
Trigonia subundulata, Jenkyn	x	x	
†Cardita polynema, Tate		x	Mornington.
Cardita scabrosa, Tate	x		Lower Maud.
Cardita delicatula, Tate	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Cardita, n. sp. - - - -			Birregurra.
*Mytilicardita sp. - - - -			
†Carditella inornata, Tate - - -		x	
†Carditella polita, Tate - - -			*Miocene*, Muddy Creek.
Crassatella communis, Tate - - -	x	x	
Protocardium hemimeris, Tate - -	x		Mornington.
Chama lamellifera, T. Woods - -	x	x	
†Montacuta, n. sp. - - - -			
†Lepton, n. sp. *aff. L. crassum* - -			Western Beach.
Dosinia densilineata, Pritch. - -		x	Table Cape.
Chione cainozoica, T. Woods - -	x	x	
†Chione, n. sp. - - - -	x		
Meretrix eburnea, Tate - - -	x		Mornington.
†Mysia subquadrata, Tate - - -	x	x	
Mysia crepidulaeformis, Tate, *m.s.* - -	x		Cheltenham.
†Mysia suborbicularis, Tate - - -	x		Cheltenham; Table Cape.
†Mysia, n. sp., *aff. M. suborbicularis* - -			
*Mysia, n. sp. - - - -			
†Donax dixoni, Tate - - - -	x		Maud; *Miocene*, Muddy Creek.
†Hemimactra howchiniana, Tate - -	x	x	
Corbula ephamilla, Tate - - -	x	x	

List of Eocene Fossils (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
Corbula pyxidata, Tate	x	x	Aldinga
*Saxicava arctica, Linn.	x		Aldinga; Cape Otway.
*Capistrocardia fragilis, Tate	x		River Murray.
†Teredo haephyii, Zittel	x		River Murray.
†Lucina leucomomorpha, Tate	x	x	
Tellina stirlingi, Tate	x	x	
Semele vesiculosa, Tate	x		Gellibrand.
†Semele krauseana, Tate	x		Mornington.
†Cuspidaria, n. sp.			
†Myodora tenuilirata, Tate	x	x	
*Myodora australis, Johnston	x	x	Table Cape.
†Myodora, n. sp.			
†Verticordia rhomboidea, Tate			River Murray.
Palliobranchiata.			
*Waldheimia grandis, T. Woods			Glenelg River.
Waldheimia garibaldiana, Davidson	x		Table Cape.
†Waldheimia sp., *aff. W. tateana*			
*Terebratula vitreoides, T. Woods	x	x	
Terebratulina scoulari, Tate	x	x	
†Terebratulina catinuliformis, Tate	x	x	

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
ECHINODERMATA.			
†Paradoxechinus novus, Laube - -	x	x	River Murray.
*Schizaster abductus, Tate - - -			River Murray.
†Lovenia forbesi, T. Woods - -		x	Portland.
†Goniocidaris sp. - - - -			
ACTINOZOA.			
Flabellum distinctum, Edw. and H. -		x	Cape Otway.
*Flabellum candeanum, Edw. and H. -	x		Gellibrand.
Flabellum pedicellare, Tate - - -	x	x	
Flabellum victoriae, Duncan - -	x	x	
Flabellum duncani, T. Woods - -			Table Cape.
Placotrochus deltoideus, Duncan - -	x	x	
Placotrochus elongatus, Duncan - -	x	x	
Placotrochus, n. sp. - - - -	x		Table Cape.
†Sphenotrochus sp. - - - -	x	x	
Notocyathus australis, Duncan - -	x	x	
†Notocyathus viola, Duncan - - -	x	x	
Notocyathus excisus, Duncan - -	x	x	
†Notocyathus alatus, T. Woods - -		x	River Murray

LIST OF EOCENE FOSSILS (*Continued*).

Name of Species.	Muddy Creek.	Spring Creek.	Other Occurrences.
†Notocyathus punctatus, Tate, *m.s.*	x	x	
†Notocyathus sp.	x	x	
Notocyathus ? sp.	x	x	
Conocyathus cyclostatus, T. Woods	x		Camperdown.
Trematotrochus fenestratus, T. Woods	x	x	
*Paracyathus supracostatus, Dennant			Table Cape.
†Deltocyathus italicus, Edw. and H.		x	Table Cape.
Ceratotrochus typus, Sequenza			Cape Otway.
Ceratotrochus sp. (*Smilotrochus vacuus*, *T. Woods*)	x	x	
†Ceratotrochus, n. sp.		x	Curlewis.
Conosmilia anomala, Duncan	x		Moorabool.
Conosmilia striata, Duncan	x	x	
Conosmilia elegans, Duncan			Gellibrand.
†Conosmilia bicycla ? T. Woods	x		Curlewis.
Bathyactis lens, Duncan	x	x	
†Balanophyllia australiensis, Duncan	x	x	Cape Otway.
*Balanophyllia armata, Duncan, *var.*	x		Corio Bay.
†Balanophyllia sp., *aff. B. tubuliformis*			
†Isis sp.	x	x	
†Isis sp.			

Miocene Beds.

In August, 1896, we described a miocene outcrop near the cemetery at Shelford (Sec. IV.). We then expressed the opinion that the sediments rested upon basalt of miocene or pre-miocene age, but that they were not in turn covered by another and later lava flow. Since then, Messrs. Hall and Pritchard have announced that the miocene of the adjoining river valley, the Moorabool, is clearly overlain by basalt, and they therefore suggest that such may also be the case on the Leigh. They are quite right, and we unreservedly withdraw our previous statement to the contrary. There is, in fact, one flow of lava at a lower level than the miocene conglomerate, and also an upper and wholly distinct flow resting upon it. The section we gave is correct as far as the surface outline is concerned, but, instead of being a superficial deposit only, the miocene should be shown as passing into the hill just underneath the basalt which caps its summit. In support of our revised opinion we offer the following evidence.

A narrow gully close to the township, on the western bank of the river, shews massive blocks of the miocene conglomerate containing casts of fossils. The thickness of the deposit could not be accurately estimated, owing to the débris which covers the floor of the gully. Above the blocks, and lying right upon them, there is a jointed vesicular basalt. No mistake can be made about this section. Both rocks are undoubtedly *in situ*, and, by the weathering of the miocene boulders, the under surface of the upper basalt is for a short distance in the hill plainly disclosed. The elevation of this junction is, by aneroid, 195 feet above datum line. For about 25 feet lower down we observed ironstone blocks on the floor of the gully, when they give place to limestone, which, from the occurrence of *Schizaster abductus* in it, we consider to be eocene. The older basalt crops out still lower down at a height of 105 feet, but whether it passes under the limestone, or is only banked up against it, we were unable to determine. The base of the basalt is not visible, being concealed by surface soil.

From this gully the miocene boulders carrying fossil casts were traced uninterruptedly in a southerly direction as far as the Red Bluff, where, as we have already recorded, they are again seen to

pass under the upper basalt. Where the lower basalt exists, viz., for about three-fourths of the distance towards the Bluff, the conglomerate is always superior to it, and in some instances clearly rests upon it. The miocene, in fact, occurs in a very shallow depression or rather gentle curve on the side of the hill between the upper and lower flows.

Whether at the cemetery, and also in places along the bank, there is eocene limestone immediately beneath the conglomerate we could not definitely decide, but, judging from the two gully sections described, we think it highly probable that such is the case. The uniformly superior elevation of the ironstone boulders to the lower basalt is, however, so apparent that we made use of them both up and down the river to trace the inner or hillside outcrop of the latter rock.

To the north of Shèlford, though there is abundant ironstone, we have not, so far, noticed any fossils in it. By a rigorous search fossils may perhaps yet be found there, but, even if not, the persistence of the deposit, together with its similar relations to the other rocks, sufficiently indicates its contemporaneous origin with the fossiliferous boulders lower down the river. Above a certain elevation, the blocks may become unfossiliferous simply because the tide level of the miocene sea is overpassed.

If the views here expressed are correct, it follows that considerable areas in this neighbourhood which have been hitherto classed as pliocene must be instead referred to the miocene period. Wherever ironstone occurs in the Geelong district underlying basalt of corresponding age to the upper flow on the Leigh there is, we think, presumptive evidence that it is a miocene deposit.

A catalogue of the fossils obtained from the miocene at Shelford was given in our former paper. Similar casts have been noticed in the blocks since collected. A few other species might perhaps be added by taking moulds of the casts, but as their miocene age is now generally admitted, the labour was regarded as unnecessary.

We searched the eastern bank of the river south of the bridge some time ago for miocene fossils. After breaking up a large number of ironstone boulders, we found some casts of species, identical with those previously listed, at a section (No. III.),

about half a mile lower down the river than Section IV. Its elevation is, however, the same, viz., abont 150 feet above datum line. By examining this bank at corresponding levels other outcrops of the conglomerate would no doubt be discovered.

As before stated, the upper basalt is entirely wanting on the eastern side of the river from Inverleigh right up to the escarpment opposite Dog Island. Still the two banks are of about equal height, and at first sight one is apt to think that the basalt which caps the western ridge once spread as a level sheet right across the gorge. A more correct conclusion, however, appears to be that the stream here marks a geological boundary, and that the lava, when deposited was banked up against the pre-existing tertiary strata. The junction of the igneous with the sedimentary rocks thus denotes the line of the most easily formed drainage channel, which, by continual enlargement, has finally resulted in the present wide and deep gorge of the river.

The non-existence of basalt in the strip of country enclosed by the lower courses of the Leigh River and Native Hut Creek is shown on the geological map of Victoria. Immediately the latter creek is crossed at Teesdale, basalt is again encountered, and the two streams mentioned therefore indicate the boundaries of what were probably separate lava flows, the one from the west and the other from the east.

Possibly some remnants of the lower basalt may exist on the eastern side of the river south of Shelford, but if so, they are very slight, and we judge that the miocene there rests directly upon the eocene. The latter is certainly not visible just where we record miocene fossils; but since it crops out higher up the river at the bridge section, and also lower down at Farrell's, its continuance under the ironstone right along the bank may be reasonably inferred.

It has been previously mentioned that, at the two eocene sections just quoted, the uppermost rocks consist of ironstone in boulders. We examined these, but failed to discover any signs of fossils in them. Similarly, along the upper margin of the eastern bank, as well as on the table-land back from the river, there is abundant ironstone, in which also we have not, so far, detected any organic remains. On the strength, however, of the fossil-bearing boulders in their vicinity, we class the ironstones

generally on this side of the river as miocene. Presumably, also, their continuation on the plain as far as Native Hut Creek represents a contemporaneous deposit.

A peculiar feature of the eastern bank is the presence in one or two places of masses of drift sand. The most notable of these is nearly opposite Farrell's; and when passing along the road from Shelford to Inverleigh, on the opposite side of the river, the contrast of the white sand with the surrounding green herbage on the bank is very striking. This sandy patch covers several acres, and, commencing at the top of the bank, passes down to about the level of the drift clays of Sec. I., which is not more than 100 yards distant. Amongst the sand there are quartz pebbles, occasional pieces of slate, and also a few small scattered boulders and balls of basalt. Higher up the river, and not far from Sec. III., there is at the very top of the bank a sandy mound similar to that at Farrell's, but of less extent. Here also we noticed a few very small detached boulders of basalt, together with rounded pieces of scoria, in one of which was a crystal of augite. This sand heap is probably the site of a blacks' camp, as we picked up a number of quartz chips (so-called flint knives), and also a piece of igneous rock foreign to the locality, and shaped into an axe-head. In both places, the basaltic fragments were found not on the surface of the mounds, but lying on patches of ground from which the sand had been partly removed by the wind. Judging by the intermixed fragments of slate, the sand would seem to be a drift from the upper reaches of the river when this was flowing at a higher level. If the scattered pieces of lava are also a part of the drift, they could, from their elevation, only have been derived from the upper basalt. On such a supposition, the drifts would of course be subsequent to the outpouring of the lava, and prior only to the recent alluvium on the margin of the stream.

Basalts.

In describing the sedimentary strata, we have necessarily made frequent reference to the associated basalts. Of these, there are probably several distinct flows on the river banks, some of which are undoubtedly contemporaneous or nearly so; such is, however,

not the case, for one of them, which, according to the evidence already produced, must have preceded the rest by a long interval of time. This lower or more ancient flow is well marked on the western bank from the township to within half a mile of the Red Bluff, where it terminates in a narrow tongue of land, and is seen no more. At this point it is still 110 feet above the river.

In making the main road from Shelford to Rokewood up the steep hill leading to the table-land, the basalt has been cut through, and a good section is obtained. Here it reaches to a height of 105 feet above datum line, and is apparently in sheets which incline towards the hill at an angle of 4°. We asked some workmen who were quarrying the basalt close to this section what they expected to find beneath it. They replied "limestone," and that without going to any great depth. They are undoubtedly right, but the difficulty with the lower basalt is not as to the strata which underlie it, but as to its relation to the limestone often met with at a higher level. Our experience in reference to one section will illustrate what we mean. Just below the cemetery, and at a height of 120 feet, there is a marl pit from which lime has been obtained for manuring the adjoining land. Lower down, the bank is covered with basalt, which is proved to be *in situ* by a quarry with massive rock showing. We thought at first that this basalt might pass under the limestone, the eocene character of which was determined on fossil evidence. The owner of the land obligingly sank a hole three feet deep at the base of the marl pit, making its total depth about 10 feet, which should, by the respective levels of the outcrops, have reached the supposed basalt underneath. On the contrary, he bottomed on solid massive limestone. He also gave it as his opinion that we should probably continue in the limestone by sinking lower, as he has never heard of an instance where basalt has been struck by quarrying the marls which show here and there along the bank. Higher up the river, the sections already quoted appear on the whole favourable to the view of the case here stated, viz., that the basalt is banked up against an eocene ridge instead of being an interbedded sheet. If so, it must have followed a minor depression in the older strata, and was consequently confined within narrow limits.

With regard to the relation of the lower basalt to the miocene, the evidence is conclusive. There are many sections showing the former rock with eocene strata directly underlying, but nowhere is there a trace of the miocene conglomerate in a similar position. On the contrary, it is invariably the superior rock. That it is in immediate contact with the upper eocene limestones is plainly demonstrated in several sections, but it also frequently transgresses beyond them, and then rests on the basalt. In all probability the volcanic rock was once entirely covered by the conglomerate, from which it has been in part removed by fluviatile action.

The cross section shown in the plate is intended to illustrate the *supposed* relation, on the theory just stated, of the lower volcanic to the eocene and miocene strata. If this approximately represents the disposition of the rocks below the surface, it is plain that in an eroded gully there may be limestone cropping out at a higher level than the basalt, though the latter is a subsequent deposit. The surface outline of the section is constructed from observations on the right bank of the river below Shelford.

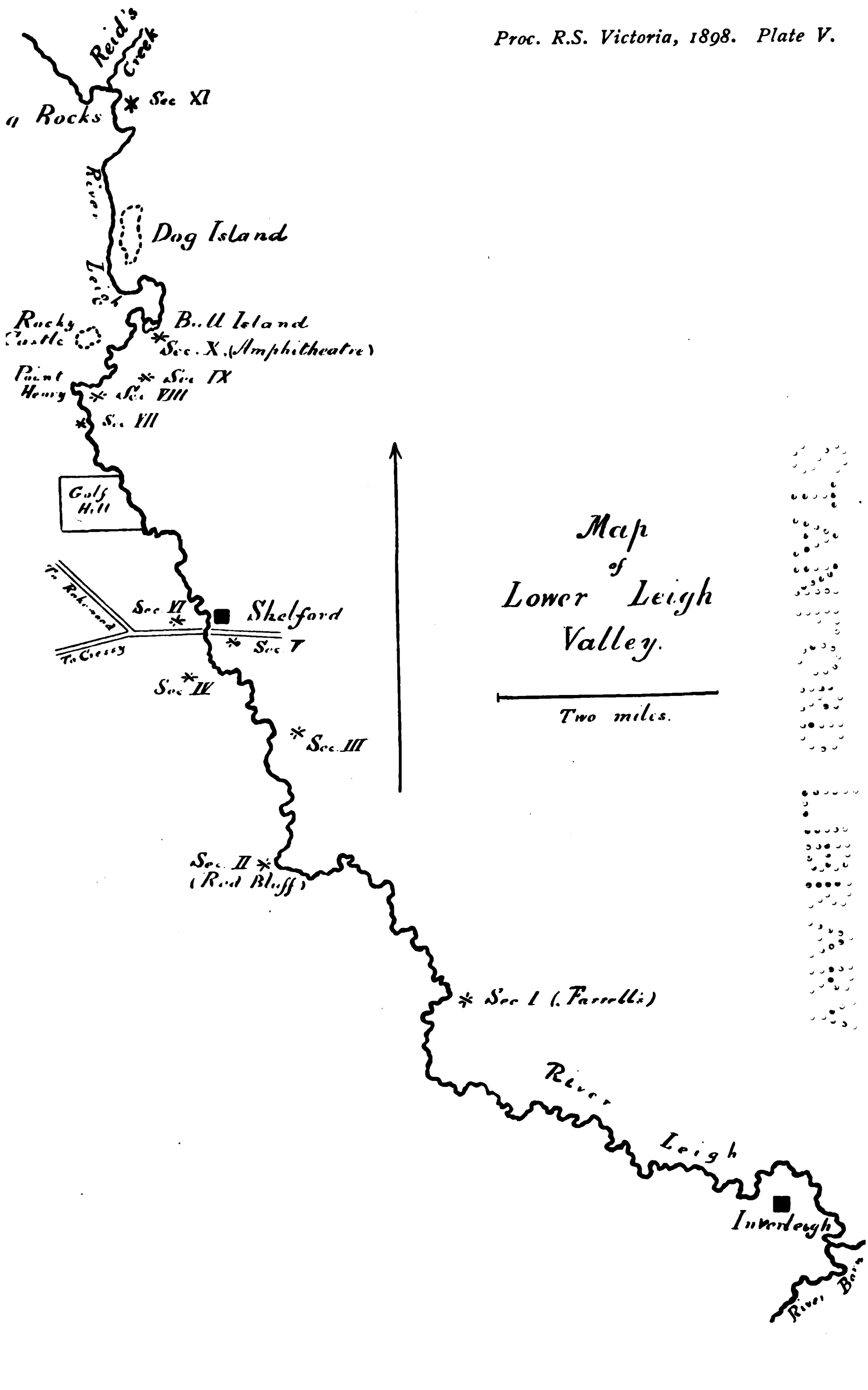
In endeavouring to trace the course of the lower basalt in the gorge of the Leigh, we will start from the north, as it has apparently flowed in a southerly direction. Only the ruins of the flow are in reality now present, a great part of it having been undoubtedly disintegrated and carried away by the action of the river. There are several prominent rocky eminences close to the bed of the river, the most notable of which is Dog Island. Another is known locally as Rocky Castle, and a third as Point Henry. Other minor knolls exist also here and there, one or two of which we have incidentally referred to before. Messrs. Etheridge and Murray, in speaking of these basaltic outliers, recognise that they mark the course of a lava flow, though the question as to whether it is distinct or not from that on the plains is left untouched. We quote their remarks in full:—"From the southern boundary of Quarter-sheet 26 S.E., down the valley of the Leigh, a series of small elevations occur in the bed of the river, of which the Dog Island is the most conspicuous. This is a small hill rising abruptly from the alluvial flat; it is capped by a layer of basalt about ten feet

thick, but at a lower level than that of the surrounding plains. Many of the small spurs jutting on to the flats from the main bank have small basaltic outliers on them, at a level about half way between the river-bed and the table-land. This basalt is evidently not interstratified with the beds of Miocene (Eocene) age; it would therefore appear that a depression in the latter had been filled in by the basalt, forming a thin capping, and that the river, in cutting its course, took the line of this depression, leaving occasional mounds and spurs from which it failed to remove all the basalt, as, from its more durable nature, it protected the beds on which it rested."

It may be added that there is a fragmentary drift, consisting of quartz pebbles from the size of a walnut downwards, on the lava of Dog Island. Below the lava eocene limestone shows in places, but only where the surface soil has been disturbed. This again rests on the ordovician. The summit of the knoll is 130 feet above the river, while the main bank is about 110 feet higher. The latter is capped by the upper basalt; just beneath this, and therefore at a high level, there are several conspicuous outcrops of massive limestone similar to those at the amphitheatre.

To trace the lower basalt continuously down the river will require some detailed plotting, which we have not yet found time for, and at present we cannot pretend to do more than give a rough outline. We have already recorded that just south of Dog Island a small outlier appears on the opposite or western bank, with only 35 feet between its base and the level of the water. Rocky Castle, which is 85 feet high, is close to this spot. Still keeping on the right bank, the old lava stream, or, to speak more correctly, that remnant of it we followed, at last strikes the river at the southern end of Henderson's Flat, where it becomes conspicuous as the bold bluff of Point Henry. From here the stream has evidently cut its way right through the lava, as this now shows on both banks. The eastern branch terminates within a short distance of Golf Hill, but the western continues on until it finally runs out about a mile and a half below Shelford.

The present thickness of the lower basalt of course varies greatly according to the amount of erosion it has suffered. At Dog Island, the Survey gives it as 10 feet; at Point Henry it is 30


Map
of
Lower Leigh
Valley.
Two miles.
Reid's Creek
Rocks
Sec XI
River Leigh
Dog Island
Bull Island
Rocky Castle
Sec. X. (Amphitheatre)
Point Henry
Sec IX
Sec VIII
Sec VII
Golf Hill
Shelford
Sec VI
Sec V
To Cressy
Sec IV
Sec III
Sec II
(Red Bluff)
Sec I (Farrell's)
River Leigh
Inverleigh
River Barwon

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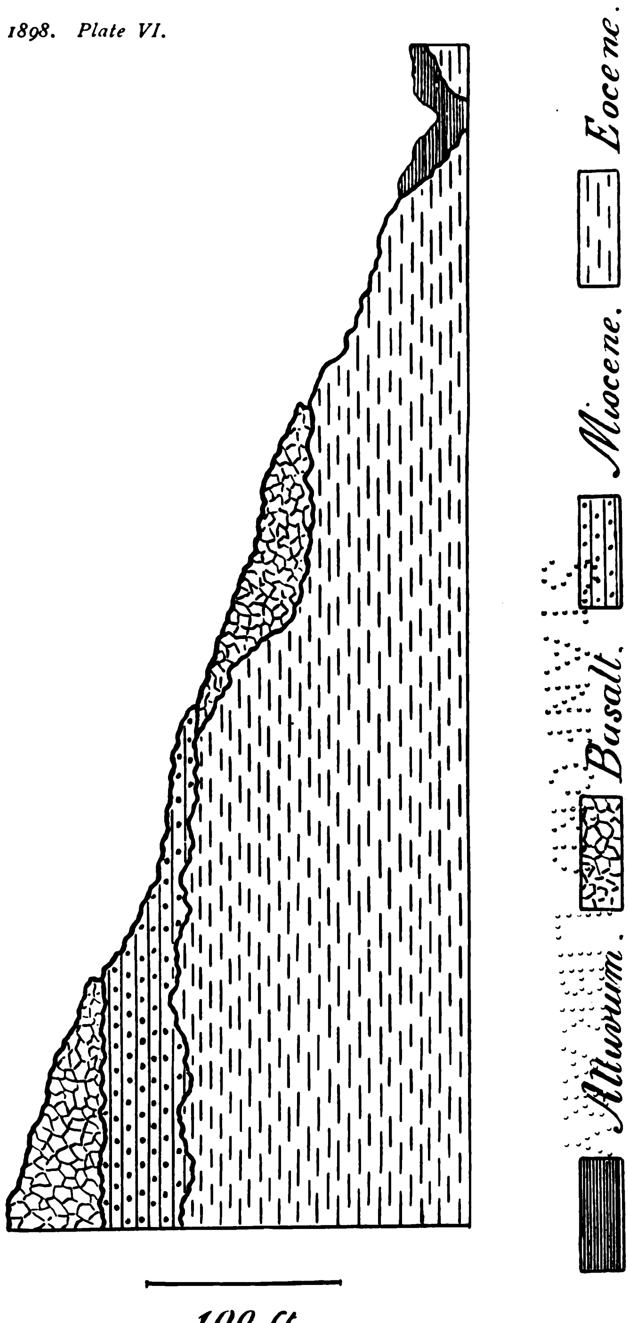
Proc. R.S. Victoria, 1898. Plate VI.



Section of Right Bank of Leigh River at Shelford.

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feet, and in one or two other sections 50 feet thick. Our former estimate of 95 feet for its thickness at the cemetery section is probably too great. There is no certainty that it reaches much higher up the hill than the site of the quarry, viz., 110 feet. It appears, however, to descend here to a somewhat lower level than usual on the bank.

We have already noted the height of the lava at the most prominent outcrops. The level of the river close to the elevation to be measured has in each case been taken as the best available zero point for aneroid work. Allowance has then to be made for the fall in the country as the river is followed down. For example, the water-level at Bull Island we found so be 80 feet above that at Shelford Bridge. By taking this into account, we estimate that the summit of the lower basalt at its southern extremity is fully 100 feet below the outcrop on Dog Island.

When speaking in our former paper of the basalt on the Leigh banks, we expressed the opinion that it could not be younger than miocene. This statement, however, is only correct in reference to the earlier flow. The upper one, which caps the miocene conglomerate, and covers the western plains, is much later, and may be pliocene or post-pliocene.

We could observe no difference in the external appearance of the rocks from the respective flows. Both are highly vesicular not only on the surface, but also for some depth down. The quarrymen tell us that the lower basalt is tougher and more difficult to crack for road metal than the upper. Possibly a microscopic analysis might disclose some variation in their mineral constituents.

By Messrs. Etheridge and Murray, the source of the newer basalt on the right bank of the Leigh is considered to be Mount Mercer, which is 17 miles north of Shelford. For that in the immediate neighbourhood of the township, we think that Gow's Hill, a point of eruption about 6 miles to the west, must be credited with having contributed at least a large portion; it is indeed not unlikely that the flow from the former vent was joined by one from the latter. In their essay, the authors named describe the courses of several distinct flows of the later basalt, some of which they trace down to and beyond the Dog Rocks. It is probable that a further study of these in the field will throw light on some of the questions raised in the present paper.

Art V.—*Contributions to the Palæontology of the Older Tertiary of Victoria.*

Gastropoda.—Part I.

By G. B. PRITCHARD,

Lecturer on Geology, etc., Working Men's College, Melbourne.

(With Plates VII. and VIII.).

[Read 9th June, 1898].

In the course of my examination of some of our Older Tertiary shells, I have frequently been met with many difficulties on account of the confusion surrounding some of our described species. It is therefore my intention from time to time to include in these contributions the results of my study upon described species, as well as to include full descriptions of undescribed material. When possible, the new species will be figured, but, failing the issue of plates with the letterpress, I hope the descriptions will be found to serve as a sufficient guide for the recognition of the species.

Lotorium pratti, T. Woods.

The first species I wish to remark upon is that described by the Rev. J. E. T. Woods under the name of Triton prattii. His original description of this species was given in Latin in the Proceedings of the Linnean Society of New South Wales for the year 1878, in a paper "On Some Tertiary Fossils from Muddy Creek, Western Victoria," and may be interpreted as follows:—Shell small, tumidly fusiform, turreted, solid, shining; whorls seven (including two embryonic), convex, girt with unequal spiral liræ, costæ obsolete, somewhat wrinkled, and everywhere closely striate, striæ minute longitudinally arranged; varices convex, broad, elevated; apex obtuse, nucleus smooth, rapidly increasing, conspicuous; aperture elliptical, dentate within, peristome produced, sharp conspicuous lip; canal prolonged, narrow and recurved.

Length, 9 mm.; breadth, 5 mm.; length of spire, 5 mm. The author in his remarks refers to the analogy of this species to Triton quoyi, Reeve, a common Southern Australian living species, the comparison being certainly a valid one. Also its small size for the genus, its remarkable mouth, "as it is murex like, dentate and almost entire." He further states that "Professor Tate regards this shell as a young *Ranella* belonging to the section in which the varices are not continuous."

This species is figured on Plate XXI., Fig. 15, of the above work, and though the figure is not a good one, it serves to indicate the shell fairly.

I should now like to draw attention to Professor Tate's description of Triton gemmulatus, in Part I. of the Older Tertiary Gastropods, as follows:—"Shell turriculate, with a distorted spire of seven convex whorls, ending in a large blunt apex of two and a half smooth whorls, with a tip very small and rather depressed. Spire whorls (excepting the apical ones) irregularly convex, being ventricose in front of, and nearly flat behind, each varix; ornamented with about 16 unequal liræ, of which there are two prominent ones on the periphery, crossed by about 15 faint intervariceal costulations which bear bead-like granulations at the intersections; the intercostal spaces distantly transversely striated.

"Varices eight, at intervals of about four-fifths of a whorl, stout, broad, crossed by the liræ, and axially striated.

"Last whorl convex, with a rounded base contracted into a short twisted beak; ornamented same as that of the spire, except that the transverse striations cut up the surface of the liræ into small granulations.

"Aperture subrotund, entire; outer lip with an acute crenulated margin, lirate within; inner lip reflected, smooth, with an oblique fold at the front. Length, 13; breadth, 6; length of aperture, 4; of canal, 2."

Professor Tate in his remarks compares the fossil with the recent Triton quoyi, Reeve, and notes the distinguishing characters. His type specimen is from the same locality as T. pratti, T. Woods. Professor Tate's figure 8*a*, *b*, on plate 6, of Gastropoda, Part I., appears to be a somewhat more finely ornamented example than that delineated by T. Woods, as the

costæ are not so well marked, the usual forms showing neat costæ distinctly, while some examples of this species are much more strongly developed in this respect, and at first sight strike one as being a distinct species, but on closer examination, they can only be regarded as varieties. On the whole, most of the representatives from the Eocene beds at Muddy Creek, Western Victoria, are finely ornamented, and more elongate, while in the examples from the Eocene clays of Mornington we note many somewhat shorter and relatively broader, with much coarser spiral threads, and coarser costæ, running into a rarer form with still stronger and as a consequence fewer costæ, and with more angulate whorls, though in the finer ornamentation and other characters of the shell, I think inseparable from the above species. The latter variety without close examination of a good series, might be taken for a new species, but fortunately it has not up to the present been described as such, and I therefore take this opportunity of expressing the opinion that it ought to be included with the present species.

In another place in Professor Tate's above mentioned work in dealing with our common Ranella, which he wrongly identifies as Triton pratti, T. Woods, he states that "Triton prattii was founded on immature specimens of what proves to be a Ranella, belonging to the sub-genus Argobuccinum, characterised by an elevated spire, short beak, and the absence of a posterior canal; and I have thought it needful to describe and figure an adult example."

Even after T. Woods was cognisant of Professor Tate's opinion about the young Ranella, he still adhered to his own opinion that it was a Triton and described it as such. So that in my opinion Professor Tate seems to have been in some way misled into redescribing Triton pratti, T. Woods, under the name of Triton gemmulatus.

The above may best be summarised as follows:—

LOTORIUM PRATTI, T. Woods.

1878. Triton prattii, T. Woods. Proc. Lin. Soc. N.S.W., vol. iii., p. 223, pl. 21, f. 15.

1888. Triton gemmulatus, Tate. Trans. Roy. Soc. S.A., vol. x., p. 126, pl. 6, f. 8.

Locality.—Eocene beds of Muddy Creek, Mornington, Lower Moorabool Valley, Gellibrand River, Curlewis, Spring Creek.

The next species that comes under notice as a consequence of the above, should my interpretation of the work of T. Woods be correct, is the very common shell hitherto referred to as Ranella prattii, but which should now have a new name. I therefore propose to call it—

Argobuccinum maccoyi, sp. nov.

1888. Ranella (Argobuccinum) prattii, Tate (non. T. Woods). Trans. Roy. Soc. S.A., vol. x., pp. 115, 116, pl. 6, f. 6.
1889. Argobuccinum pratti, Cossmann. Ann. Geól. Univ., tom. v., p. 1089.
1894. Argobuccinum pratti, Tate. Jour. Roy. Soc. N.S.W., vol. xxvii., p. 172.
1897. Apollo pratti, Harris. B. M. Cat. Aust. Tert. Moll., pp. 195, 196.

Localities.—Muddy Creek, Western Victoria; Mornington Clays; Moorabool Valley; Curlewis; Gellibrand River; River Murray Cliffs near Morgan, South Australia. From deposits of Eocene age at the above localities.

Observations.—As already indicated, Professor Tate regarded this species as representing the adult of Triton pratti, T. Woods, and clearly seeing that the description of T. Woods did not altogether suit this shell, he therefore described and figured the present species, with T. Woods' name erroneously attached, thinking to amplify the previous work.

This species is somewhat variable in many respects, the large coarse form represented by Professor Tate in his Tertiary Gastropoda, Plate VI., Fig. 6, being by no means the commonest or most generally distributed form in Victoria. I believe this is the prevailing form at the Murray River section, South Australia, it also occurs at Muddy Creek, but at most of our localities the prevailing form is finer in ornament, with the tessellated character of the whorls very distinct, the somewhat nodulose costæ of the body-whorl being almost if not entirely absent, while the shells are not of such a robust character, at the same time being relatively more elongate and not so broad.

Dimensions.—The following may serve to show more clearly some of the points I have just indicated.

Length.	Breadth within the Varices.	Length of Aperture.	Length of Canal.
29 mm.	20 mm	9 mm.	7 mm.
26 ,,	9 ,,	6 ,,	6 ,,
25 ,,	10 ,,	6·5 ,,	6 ,,
23 ,,	8 ,,	6 ,,	6 ,,
22 ,,	8 ,,	6 ,,	4.5 ,,
20 ,,	7 ,,	5 ,,	6·5 ,,

The first of the above being the dimensions given by Professor Tate.

Bathytoma rhomboidalis, T. Woods.

1879. Pleurotoma rhomboidalis, T. Woods. Proc. Lin. Soc. N.S.W., vol. iv., p. 10, pl. 2, f. 9.

1892. Dolichotoma atractoides, Tate, m.s., Pritchard. Cat. Tert. Fossils, Ann. Rep. S.A. School of Mines, p. 200.

1893. Dolichotoma angustifrons, Tate and Dennant. Trans. Roy Soc. S.A., vol. xvii., pt. i., p. 221.

1894. Genotia angustifrons, Tate. Jour. Roy. Soc. N.S.W., p. 175, pl. x., figs. 7, 7*a*, 7*b*.

1894. Dolichotoma atractoides, Tate, m.s. (non. G. atractoides, Watson). *Id.*, p. 175.

1897. Bathytoma angustifrons, Harris. B. M. Cat. Aust. Tert. Moll., pp. 49, 50.

Localities.—Muddy Creek; Moorabool Valley; Gellibrand River; Mornington; Bairnsdale; Point Campbell; Lake Connewarre; Newport; Altona Bay; Royal Park (lower beds); Beaumaris (Eocene limestone pebbles). All the above occurrences being of Eocene age.

Observations.—In his original description T. Woods gives fairly full particulars of the young of this species. He was also perfectly aware that he was describing only a young shell, but he regarded his specimen as "sufficiently developed to determine its character." Owing to this his description appears to be somewhat fuller and more careful in detail than usual.

As this is one of our commonest shells, young examples are not particularly rare, and by a careful comparision of these with the original description and figure, there cannot possibly be any doubt as to the species indicated. From the very young examples it is an easy matter to make up the grades to the more ordinary adult forms. Although Professor Tate and Mr. Harris and others have worked with this species they have either been unable to interpret T. Woods' work or have overlooked it, for Professor Tate[1] states that "Pleurotoma rhomboidalis, Tenison Woods, has no specific characters, it represents the tip of a Bathytoma." Mr. Harris in the British Museum Catalogue accepts Professor Tate's description of 1894, but some of his remarks have an interesting and important bearing on my present treatment of this species; he states: "It is interesting to observe also that but few of the main features of the ornament were foreshadowed in the brephic stage, and the extremely diversified character of that ornament as the animal became adult is merely an individual characteristic of no value for systematic purposes. If the shells of a number of very young specimens be compared, no one would have any difficulty in relegating them to a single species; but as they get larger the ornament tends to become so variable that many malacologists would feel inclined to admit the extreme types of variation as of specific rank."

In view of the evidence before us it seems only right to recognise and retain T. Woods' species.

Solutofusus, gen. nov. Pl. VII., Fig. 1, 1*a*, 2.

Shell narrowly elongate, somewhat fragile on account of its thinness. Embryo smooth, consisting of about two and a half contiguous, but rather deeply sutured, whorls, making the apical whorl appear somewhat angulate medially, whorls of about uniform breadth, with a prominently exsert and eccentric tip, the latter standing erect about half as high as the breadth of the embryo, and near the junction with the spire the embryo becomes faintly costulate.

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[1] Jour. Roy. Soc. N.S.W., 1898, vol. xxxi., p. 398.

Spire a little more than half the length of the shell, the first spire whorl being in contact with the preceding embryonic whorl, but the succeeding ones becoming more and more unrolled forming a vermetiform spiral round a very slender axis. Posterior spire whorl somewhat strongly costate, but the costæ may become more or less obsolete towards the body whorl. The whole of the spire is adorned with strong spiral threads in the type species, the whorls being convex to an approximately medial angulation.

Aperture small and oval; inner lip enamelled within, very thin, and well defined from the columella, with which it merges only at the extreme anterior end; outer lip also very thin and closing in so close to the columella anteriorly as to appear almost entire, and the long anterior channel shows externally only as an extremely narrow slit, but the end section shows a relatively large internal space which is almost circular. The axis of the shell round which the whorls are coiled is somewhat undulate, hence its extension into the long snout partakes of the same character, and is more or less arched or twisted like a siphonalia. Canal a little more than one-third the length of the shell.

Solutofusus carinatus, sp. nov. Pl. VII., Fig. 1, 1*a*, 2.

Shell thin, very slender, with a smooth embryo of about two and a half whorls, which appear angulate medially with a rather deep and well-defined suture, the eccentric apex is sharp, and exsert for about one-third to one-half of a millimetre; the embryonic whorls are in contact with each other and with the first spire whorl, and though they increase slightly in size towards the spire yet they are of about uniform width, the last half turn becomes slightly costulate as it joins the spire, about two to three costulæ being visible before the more complex ornament appears. The apparent angulation mentioned above may be regarded as a correct description for the apical whorl, but the succeeding whorl being almost flat medially, and the sutural excavation being so deep, it appears doubly keeled, this feature becoming less distinct as the whorl becomes more convex. Spire whorls five, remarkably disjoined, the space between each whorl increasing towards the aperture, and the whorls gradually increasing in diameter, but the latter increase is much less than

that of the intervening space, the ratio being about one to two. Earlier spire whorls costate, the first bearing about seven costæ, which are strongest medially, thinning out towards the posterior suture and also on the anterior slope. The costæ on the succeeding whorls gradually become less distinct till their position is only discernable by a slight angulation of the keel.

Whorls encircled by strong spiral threads about twelve to fourteen in number, two of these being more strongly developed than the remainder, one margining the deeply excavated suture, and thereby making the shell more angular at this region, while the other forms the prominent and characteristic encircling keel. The spiral threads are broad and flattened, but narrower than the intervening spaces, the latter occasionally but not regularly showing a faint spiral thread or faint spiral striæ. The remaining ornament consists of very fine close-set lines of growth, which are more distinct in the intervening spaces.

Aperture ovate; peristome very thin; inner lip quite distinct from the columella; outer lip undulate, channelled interiorly corresponding to the spiral threads, the latter projecting slightly at the thin edge, the most marked projections being at the end of the sutural and medial keels. Outer lip contracted so closely to the columella as to give the aperture the appearance of being entire, but really opening into a long slender slightly waved canal, the opening of which is contracted to an extremely narrow slit. The threads on the canal are narrower and more angled than those on the spiral whorls.

Dimensions.—Length of shell, 30 mm.; breadth, 7 mm.; breadth of aperture, 2 mm.; length of aperture, 3 mm.; length of canal, 10 mm. The above dimensions are those of the type specimen, but appear to be about the average of the specimens yet obtained, with the exception of the imperfect example figured on the accompanying plate, which is proportionately larger, the breadth of its aperture being 2·5 mm., length of aperture, 3·5 mm., and length of canal, 13·5 mm., the latter being much more waved or bent than in the type.

Locality.—Eocene clays of Balcombe's Bay, Mornington, and Curlewis; also from the Eocene beds of Muddy Creek, Western Victoria.

Murex wallacei, sp. nov. Pl. VII., Fig. 3.

Shell robust, ovately biconic; consisting of six and a half whorls, including one and a half smooth, convex embryonic whorls, the remainder being very perfectly and neatly sculptured.

Varices three, not being very prominent till the third or fourth whorl is reached, but strongly developed on the body whorl, where the shell appears first to have had a thin foliaceous lip extended into a delicate, erect, wing-like expansion, and subsequently the base of this has become considerably thickened by successive laminæ, each of which is distinctly seen as it terminates a little short of the one preceding it, thus completing the anterior aspect of these well-marked varices. Posteriorly each varix partakes of the ordinary sculpture of the whorls. The varices are not regular, but rather strongly sigmoidal. Whorls rather ventricose, with a deeply impressed suture, and bearing about the middle of the intervariceal spaces a somewhat angular nodosity. Ornament on the earlier spire whorls consisting of about three or four strong spiral threads, transversely crossed by fine læmellæ of growth which are most prominent and scaly where they cross the spiral threads, on the succeeding whorls there are a few more spiral threads visible, generally with one or two finer intervening threadlets, till on the body whorl there are about ten strong threads with fine intervening threadlets, and still finer spiral striæ, the whole regularly and closely crossed transversely by growth lamellæ.

Aperture almost quadrate, the upper and outer angle being formed by the well-marked posterior canal, peristome thickly enamelled and distinctly effuse over the body-whorl. Outer lip with a somewhat crinkled edge, and strongly dentate within, bearing about ten or twelve oval denticles which cease at the commencement of the canal; effuse inner lip slightly raised, continuous, and distinct to the canal. Columella slightly bent, and at the posterior end of the canal bearing about three raised denticles, similar to those on the outer lip. Snout broad, umbilicus slight, canal about half closed, though wide and deep, and making but a slight angle with the axis of the shell.

Dimensions.—Length of shell, 30 mm.; breadth of body-whorl between the varices, 20 mm.; breadth, including varices,

28 mm. (slightly imperfect); length of aperture, 10 mm.; breadth of aperture, 7 mm.; length of canal, about 10 mm.

Locality.—Eocene clays of Mornington. Collected by Mr. W. Wallace.

Observations.—This very pretty and distinct species was collected from the Mornington clays by a past geology student of mine, Mr. W. Wallace, of the Department of Mines, Melbourne, and I have therefore much pleasure in associating his name with this shell. Its characters are so very well marked and distinctive, that I do not think it can be easily confused with any of our previously described fossil species.

Voluta fulgetroides, sp. nov. Pl. VII., Fig. 4.

Shell robust, fusiformly oval; spire about one-third the length of the shell, or a little less, terminating in a smooth convex mammillate embryo of one and a half to two obliquely enrolled whorls of moderate size, whose apex is laterally immersed. In addition to the embryonic whorls, there are three or four, generally four, convex whorls, the body-whorl of some specimens being somewhat more tumid and regularly rounded from the suture than others. Suture distinct, somewhat impressed; the whorls are ornamented with very fine close spiral striæ, tending to become obsolete on the body-whorl in most specimens, occasionally several fairly strong spiral threads show on the body-whorl; the lines of growth are well marked and occasionally through their irregularities give rise to slight undulations. This species was to all appearances colour-marked, judging by certain irregular brownish patches, but these are not sufficiently defined in the present specimens to accurately indicate their nature.

Aperture elongate oval, about two-thirds the length of the shell. Inner lip strongly enamelled with a much thickened pad at the posterior end in the adult; columella furnished with three to four strong oblique plaits; outer lip much thickened, this character being most marked medially, becoming thinner anteriorly and posteriorly, and marginally reflected, ascending the penultimate whorl for about one-third its height, and distinctly continuous with and merging into the enamelled inner

lip; a distinctly defined posterior canal can be seen. Anterior canal broad, but relatively shallow, the anterior extremity of the outer lip usually falling short of the columellar extremity by about seven to ten millimetres.

Dimensions.—Length of shell, 118 mm.; breadth, 63 mm.; length of aperture, 88 mm.; breadth of aperture, 22 mm.; breadth of canal, 13 mm.; greatest breadth of embryo, 9 mm.; the above dimensions refer to the type specimen, but much larger examples have been obtained, as may be seen by the following:—Length, 145 mm.; breadth, 77 mm.; length of aperture, 108 mm.; breadth of aperture, 30 mm.; breadth of canal, 20 mm.; greatest breadth of embryo, 10 mm., for the loan of which I am indebted to Mr. W. H. Green.

Locality.—Miocene beds of Muddy Creek, and of Grange Burn, Western Victoria; also from the Miocene deposits of Beaumaris (Mr. J. A. Atkinson).

Observations.—As indicated by the above dimensions, the type is not the largest representative of the species, but is a somewhat short, broad, and slightly more tumid form, with an abnormal peculiarity about the aperture, which can be seen in the accompanying figure. After the shell had apparently assumed its adult form and perfected its outer lip, for some reason or other another growth of shell was commenced, leaving the thickened lip behind as a varix, and though at present the edge of this secondary growth is imperfect through fracture, apparently before preservation, it projects beyond the original lip for about twelve millimetres and is about two millimetres thick at its strongest part, thinning a little anteriorly.

The species to which this shell bears the most striking general resemblance is the living Voluta fulgetrum, Sowerby, of South Australian waters, but from this it may be distinguished by its embryonic characters, the embryo being larger, broader, and obliquely enrolled, and hence the immersed apex is eccentric, further by the absence of the shouldering of the body-whorl, by its well thickened and reflected lip, and by the sutural and other characters.

In some respects the present species appears intermediate between Voluta fulgetrum, Sowerby, and Voluta fusiformis, Swainson, but it does not possess the small embryo and rela-

tively slender spire of the latter species, though the characters of the outer lip are more closely allied, but even here there are distinct differences.

Voluta hamiltonensis, sp. nov. Pl. VIII., Fig. 5.

Shell fusiform, with its spire less than half the length of the shell, capped by a remarkably large smooth mammillate embryo.

Embryo varies in size from about fourteen to ten millimetres in diameter, and from eleven to ten millimetres in height, and has a much swollen appearance, consisting of two obliquely enrolled whorls, their axis of enrolment making an angle of from forty to fifty degrees with the axis of the shell.

Embryonic whorls succeeded by four very slightly convex whorls with an impressed suture, and bearing faint spiral striæ, a few of the striæ tending to become stronger and more thread-like on the anterior slope of the whorls. The spiral ornament is crossed transversely by very fine regular lines of growth, which on the earlier spire whorls are somewhat sigmoid, but soon become backwardly arched to a less degree; in some specimens the lines of growth become so strong and raised as to give rise to narrow liræ. Body whorl somewhat flattened medially on the back. Young shells of this species are much more strongly spirally striate on the rather abrupt anterior slope towards the notch.

Aperture lanceolate; outer lip barely ascending the penultimate whorl where it joins the much thickened and conspicuous enamel pad of the inner lip; outer lip thickened, reaching its maximum in this respect about two-thirds the distance from the suture, and being almost margined within, while without, the margin is distinct. Columella bearing in the young shells three plaits, but adults show some variation by the presence of two additional smaller plaits, one between the anterior and the next above it, and the other forming part of the strong callosity above the posterior one. The colour marking preserved shows that this species bore narrow zig-zag lines of a reddish or brownish colour, parallel to one another, and about five or six millimetres apart.

Dimensions.—Length of shell, 115 mm.; breadth of shell, 45 mm.; length of aperture, 65 mm.; breadth of aperture, 16 mm. Young examples give the following measurements in the above order, 50, 24, 30, 12, and 45, 21, 27, 10.

Locality.—Eocene beds of Muddy Creek, Western Victoria.

Observations.—One remarkably interesting feature about this species is the preservation in one of the adult specimens of the colour marking, which is similar to that so well known on the usual form of Voluta undulata, Lamarck, but differs in not being quite so frequently bent, about two angulations only being noticeable, and in that the lines of colour are much further apart and therefore fewer.

This species might at first sight be taken for Voluta ancilloides, Tate, but when closely examined numerous points of difference arise which seem at present to necessitate the introduction of a distinctive specific name for this shell. Some of the distinguishing points may be summed up as follows: the embryo of the present form is of much more gigantic proportions, and more obliquely enrolled, and the general habit of the shell indicates several points of difference, the whorls are not so ventricose, though the suture is more deeply impressed, and the young shells are much more suddenly contracted to the anterior end, there are also minor differences in the spiral ornament, and in the characters of the thickened lip.

Voluta gatliffi, sp. nov. Pl. VIII., Fig. 6.

Shell ovately fusiform, with prominently angled and strongly costate whorls; the spire, though prominent, is less than half the length of the shell, and is terminated by a mammillate apex, consisting of from one and a half to two smooth swollen whorls. Embryonic whorls obliquely enrolled with a laterally immersed tip, the axis of enrolment making with the axis of the spire-whorls an angle of about forty-five degrees.

In addition to the obliquely enrolled portion, the succeeding half whorl at least, and sometimes a complete whorl, shows embryonic characters, in the earlier portion smooth, or showing lines of growth, then wrinkles, which develop into angulate nodules, and ultimately extending down the whorls into strong,

well-marked angulose ribs. The fine spiral thread-like ornament commencing with the wrinkles.

In addition to the above, there are about three strongly shouldered whorls bearing narrow, oblique, forwardly-directed costæ, the number of which is somewhat variable, ranging from twelve to sixteen or seventeen on posterior whorl, to about fourteen to twenty-two on the body whorl. At the shoulder the costæ are very prominent and abruptly angled, but fade out rapidly before reaching the suture, and at the same time are forwardly directed in conformity with the lines of growth; on the anterior slope of the body-whorl the costæ are slightly forwardly arched, crossing the lines of growth at an acute angle, while, towards the notch they become backwardly arched as they gradually fade out. The concave interspaces between the costæ are usually broader than the costæ, but in the more closely costate forms the spaces are very slightly, if at all, wider than the breadth of the ribs. Earlier whorls closely spirally threaded, tending to become obsolete anteriorly, till on the body-whorl a few threads can sometimes just be detected near the suture.

Aperture ovate, with a somewhat thickened and reflected outer lip, slightly ascending the penultimate whorl, and most strongly effuse or reflected posteriorly, giving the appearance of a small almost wing-like expansion. Columella rather strongly twisted and bearing about its middle three thin oblique plaits. Outer lip falls considerably shorter than the end of the columella; the aperture at the anterior end being relatively very broad and open.

Dimensions.—Length of shell, 69 mm.; breadth of shell, 33 mm.; length of aperture, 44 mm.; breadth of aperture, 15 mm.

Locality.—Eocene beds of Muddy Creek, Western Victoria.

Observations.—This form is very distinct from any of our previously described species of this genus, and it affords me much pleasure to name it after my friend Mr. J. H. Gatliff, in recognition of his long and careful work amongst our living Victorian Mollusca.

Voluta pueblensis, sp. nov. Pl. VIII., Fig. 7.

Shell regularly fusiform, with an acute spire about one-third the length of the shell, terminated by a bluntly convex embryo of about two smooth whorls, which are enrolled in the same plane as the spire whorls, and with a centrally immersed tip.

Succeeding whorls four, the earlier being almost flat, becoming slightly convex, the convexity being most marked where the slight costæ are developed. The costæ consist of slight narrow raised undulations with broad shallow interspaces, the costæ being most prominent about the middle of the whorl, fading out before reaching the posterior suture but reaching to the anterior suture, while on the body whorl they soon thin out on the anterior slope. The costæ number about twelve posteriorly whilst on the body whorl they show a tendency to become obsolete, about ten can usually be counted. Parallel to the costæ there are somewhat coarse lines of growth, and transverse to them spiral threads are distinct on the posterior whorls, but gradually fade out towards the body-whorl where they can only be seen on the upper portion of whorl down to the gradually sloping shoulder.

Aperture narrow elongate, columella slightly twisted and bearing four strong oblique plaits. Outer lip thin and sharp at the edge, not ascending the penultimate whorl. Canal broad and deep.

Dimensions.—Length of shell, 55 mm.; breadth of shell, 19 mm.; length of aperture, 32 mm.; breadth of aperture, 6 mm.

Locality.—Lower horizon of the Eocene beds of Spring Creek, south of Geelong.

Observations.—In some examples of this species the costæ are somewhat more marked than in the figured specimen, and are in the form of acute narrow and more elevated ridges. This species is most closely allied to Voluta sarissa, Tate, which may possibly account for the record of that species in these beds.[1] The present species may however be readily distinguished from Voluta sarissa, Tate, in general habit, by its short spire, its very distinct embryo, several points in its ornament, and general proportions.

All the types of the herein described species are in my own collection.

In conclusion I beg to convey my best thanks to Mr. T. S. Hall, M.A., for the time and care he has been good enough to bestow on the drawings of these shells, for the value of the present paper is much enhanced by the accompanying plates from his drawings.

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1 Trans. Roy. Soc. S.A., 1893, p. 220.

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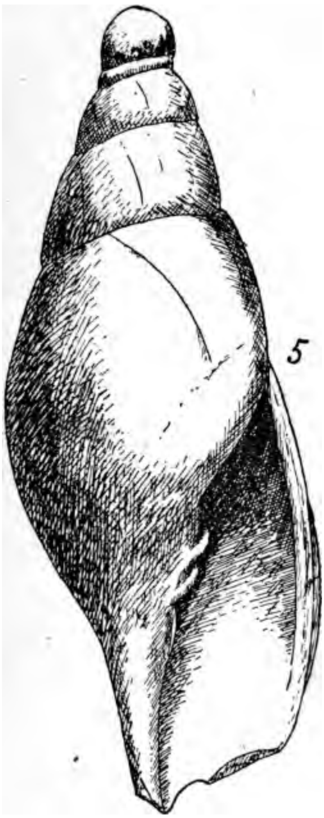

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EXPLANATION OF PLATES.

Fig. 1.—Solutofusus carinatus, gen. et., sp. nov. Type. Eocene. Balcombe's Bay, Mornington.

„ 1*a*.—Embryonic whorls of Solutofusus carinatus. Enlarged.

„ 2.—Solutofusus carinatus, gen. et., sp. nov. Larger example, showing some points of variation.

„ 3.—Murex wallacei, sp. nov. Eocene. Mornington.

„ 4.—Voluto fulgetroides, sp. nov. Miocene. Muddy Creek.

„ 5.—Voluta hamiltonensis, sp. nov. Eocene. Muddy Creek.

„ 6.—Voluta gatliffi, sp. nov. Eocene. Muddy Creek.

„ 7.—Voluta pueblensis, sp. nov. Eocene. Muddy Creek.

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CONTENTS OF VOLUME XI.—Pt. II.

ART. VI.—*On the Structure of the Alimentary System of Gryllotalpa australis (Erichs.), with some Physiological Notes.*

By O. A. SAYCE.

(With Plates IX. and X.)

[Read 14th July, 1898.]

I desire to acknowledge my indebtedness to Professor W. Baldwin Spencer for kindly interest and help during my investigations; also, I am under obligation to Mr. T. S. Hall, M.A., who has supplied me with references and books; to Mr. T. E. Edwards for helpful literature; and to Mr. J. A. Kershaw of the National Museum, for the identification of the species.[1]

The common Victorian species of mole-cricket *Gryllotalpa australis*, Erichs., differs in the alimentary system, in no marked degree, from *G. vulgaris*, Ltr. The size of the insect is, however, smaller; the usual length of *G. australis* being 32 mm., and that of *G. vulgaris* 52 mm.

G. australis abounds very plentifully in gardens and meadow lands for some miles around Melbourne and other parts of Victoria, and may readily be traced to their burrows at sunset, in summer and autumn, by the strong shrill noise of the males. Only the females can fly.

Other localities recorded for this species, Mr. Kershaw informs me, are New South Wales, Queensland, and the Islands of Ceram, and New Caledonia. He has no record of their being found in Tasmania. Further, I hear from him that there are at least three species of the genus found in Australia.

As is well known, Gryllotalpa is omnivorous, but as far as our species is concerned, Mr. Charles French, Government Entomologist of Victoria, tells me that he has only had two reports of its destruction of root crops. I have kept them alive for months

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1 During the passage through the press of this paper I have had the opportunity of consulting Professor A. S. Packard's Text Book of Entomology (Macmillan, 1898). Wherever possible I have adopted his terminology.

with a diet of earth worms and insects, which they devour greedily, while such things as potatoes and bulbs remain untouched. Local conditions however, might affect their preference.

The Alimentary Canal.

The alimentary canal is richly supplied by tracheæ, which wrap themselves round the various organs and convolutions, and ramify among the muscles. They form the principal support of the digestive organs in the body cavity (hæmocœle).

I shall enumerate the embryonic divisions of the canal and then describe its structure—

Classification of Embryonic Divisions and Parts.

It comprises three main divisions :—

1. *The Fore-intestine*, which is of ectodermic origin and corresponds to the stomodæum of the embryo, includes the mouth, salivary glands, pharynx, fore-gullet, crop (ingluvies) hind-gullet and proventriculus (gizzard). On account of dissimilar structure I have considered it necessary to divide the œsophagus into fore- and hind-gullet; the fore-gullet embraces the part between the pharynx and its opening into the crop, and the hind-gullet the part from the outlet of the crop to the entrance of the proventriculus.
2. *The Mid-intestine*, formed from the mesenteron, is remarkably short in Gryllotalpa compared with other of the Orthoptera, and comprises only the cæcal organs. In this I follow Cuénot (2) who differs from other writers, notably Bordas (1) of later date, who have placed the division a little anterior to the entrance of the duct of the Malpighian tubes. I shall state my reasons for so doing later.
3. *The Hind-intestine* (part of which is called mid-intestine by other writers than Cuénot) corresponds to the proctodæum. I divide this into (*a*) fore, (*b*) mid, (*c*) hind terminal canal, (*d*) rectum and (*e*) anus.

It possesses two diverticula, viz., two pairs of arborescent glands (Dufour), and the urinary or Malpighian tubes.

Salivary Glands.

A detailed description of the Salivary Glands of *G. vulgaris* is given by Bordas (1). There is no fundamental difference in *G. australis.* Briefly stated they are composed of two pairs of bunches of lobules, and two thin walled and extensible reservoirs. The smaller efferent ducts, and the ducts from the reservoirs, open into main ducts, which traverse the prothorax on each side of the œsophagus, pass below the ganglia, and meet to form a very short common duct that opens behind the lower lip and under the lingua. Of the two pairs of bunches of gland cells, the anterior pair, located in the mesothorax, is the smaller; they in part meet and surround the œsophagus.

The posterior pair, situated principally in the metathorax, is larger, and, in contrast with Bordas's experience, I have generally found them to stretch as far back as the second abdominal segment, a little anterior to the testes.

The cells of the alveoli are surrounded by a thin cellular membrane. The nuclei of the secreting cells are large (25μ) and possess numerous nucleoli.

The whole of the glands and ducts originate from the ectoderm.

Fore-gullet.

The fore-gullet, leading from the pharynx passes through the occipital foramen and following a straight course through the thorax opens, at a distance of 14 mm., into the crop. When not distended by food its lumen is closed by deep longitudinal folds, but it is capable of very wide distension. Its outer wall (Fig. 2) is composed of annular and longitudinal muscle fibres (I have not determined a peritoneal layer), overlying a thin basement membrane, upon which reposes a single layer of cubical epithelial cells with large nuclei; these secrete a thick layer of hyaline chitin, bordered by strong yellow chitinous denticulations. These teeth (Fig. 2*a*), are ·2 mm. in length, laterally much

compressed, and terminate at the summit in one or more fine points. They are acutely bent at their base, and point backwards, so that they overlap one another like tiles on a roof.

Crop.

The crop or ingluvies, into which the fore-gullet opens, is a large ellipsoidal thin-walled sac, situated in the thorax. When fully distended it measures about 6 or 7 mm. at its widest diameter. In contrast to other of the Orthoptera it is situated on one side of the axis of the digestive tube. It may be considered as a large lateral expansion of a part of the wall of the œsophagus, the opposite portion of the wall continuing posteriorly for about ·5 mm., when it is met by the return of the wall of the crop to form the posterior outlet of that organ.

The histological elements are the same in kind as those of the œsophagus. In contra-distinction, its wall is much thicker, due in part to the epithelial cells which are columnar shaped, and also to the cuticle, which is thicker. The musculature is similar, viz., thin bands of muscle fibres crossing one another. The teeth are much shorter, each terminating in a point, and they project inwards like teeth of a saw, and are arranged to form rows side by side in close juxtaposition. The surface thus presents an appearance something like a rasp.

When the crop is not fully distended by food the epithelial and chitinogenous layers are thrown into deep corrugations, which radiate from the openings, and when further emptied the whole wall is deeply folded, and the organ presents a much shrivelled appearance.

Both at the anterior opening and posterior outlet the annular muscles of the gullet are much more numerous, and valves are formed by cushions on the inner wall. If inflated with air and then dissected out, I have found that only a small quantity of air escapes, the organ remaining considerably distended, which demonstrates how effectually the inlet and outlet may be closed.

Hind-Gullet.

This commences at the outlet of the crop and continues for a short distance (4 mm.) when it rapidly widens in the formation of the gizzard.

The annular muscles of this portion of the canal are more numerous than in the fore-gullet, and the wall is consequently not so distendable.

The cuticule is raised into more decided longitudinal anticlinal folds, and the whole is fringed by long fine chitinous setæ, pointing backwards; very different in structure from those of the fore-gullet.

Proventriculus or Gizzard.

The Proventriculus or gizzard is spheroidal in shape, and measures about 3·5 mm. through its long axis. It is united with the posterior end of the hind-gullet, leading from the crop. At the orifice the walls of the food-canal are raised into definite cushions, which unitedly act as a valve to close the gizzard and prevent a retrograde movement of the food.

The outer wall at the hinder extremity is reflected and joins with two cæcal organs (the mid-intestine); the inner chitinous layer is continued to form four membranous curtains, the œsophageal valve of Weismann, which hang loose and function as guards to prevent the entrance of coarse food material into the cæca.

A median transverse section of the gizzard (Fig. 4) reveals the presence on the outside of (*a*) a very thick layer of annular muscle fibres, underlying which are (*b*) longitudinal muscle fibres comparatively few in number; (*c*) a basement membrane, on which is situated (*d*) a layer of chitinogenous cells, which secrete varying thicknesses of chitin, forming strong and elaborately shaped teeth and setæ. The teeth are situated upon folds of the inner wall, and they form six definite columns, each column being similar in structure. Each column is transversely divided as far back as the radial wall by generally fourteen or fifteen definite, but irregular radial ridges, which are disposed longitudinally one underneath the other, and separated by very short distances (Fig. 3).

The appearance of a transverse section of the gizzard, showing one of these columns cut across, with the upper or anterior surface of one-sixth part of a radial ridge uppermost, is shown in Fig. 4. Each part of the ridge is similar; it will be unnecessary to describe more than one to represent the whole. They are each bilaterally symmetrical. A central fold projects into the

cavity of the gizzard for a distance of ·4 mm., capped by strong yellow chitin, bearing teeth, and spreading laterally at the summit to ·3 mm. The depth across the face, at the summit, from the upper to the under border measures ·7 mm. The centre at the summit is concave on the upper surface, and underneath is a thin lip curving somewhat upwards with four or five strong pointed teeth which project a short distance into the cavity of the gizzard (Fig. 4, M.T.). On each side of this branch two very short chitinous extensions, similar to each other, with flat surfaces, having short blunt points scattered over the surface (Figs. 4 and 5, M.T.A.). They are directed laterally with their under or posterior border fringed with four strong pointed teeth projecting outwards and curving upwards. This, as a whole, we may call the median tooth.

On each side of the lateral extensions of the median tooth are two large paired teeth, which arise from the middle fold, but nearer the radial wall and project further into the cavity of the gizzard (Figs. 4 and 5, L.T.). As each tooth arises from its base it points laterally, but curves round and upwards in a half spiral turn, to point towards the centre; thus they are more anterior in respect to the opening of the gizzard than the lateral extensions of the median tooth, and also more lateral. These lateral teeth have the under surface flat and broad, and clothed with little blunt points (Fig. 5), and this surface faces the flat surface of the appendages of the median tooth to unitedly form an obtuse angle, divided by a small space. The opposite or upper surface (Fig. 4) is rounded and possesses a row of pointed projections directed inwards, and each tooth tapers towards the apex. They are united by a band of chitin.

Longitudinal muscles follow the fold inwards for some distance.

Fringing the sides of this median fold, and hanging down somewhat underneath are chitinous membranes clothed with long fine setæ pointing towards the centre, and on each side of these arise from the radial wall two projections, with the appearance of a bluntly-pointed apex when viewed from above, as shown in the section, but they are membraneous, and the wall of each bends over downwards. They are clothed with setæ pointing centrally.

Lateral to these again are two smaller projections with depressed summits, the centre of which marks the lateral extremity of one-sixth part of the whole ridge, and from whence, on each side, commence similar parts of the same radial ridge. These lateral projections are not transversely divided, but run uninterruptedly from the anterior to the posterior extremity of the columns (Figs. 4 and 6, P.).

It must be remembered that the whole of the inner cuticle of the gizzard is strongly chitinous.

The anterior eleven or twelve transverse ridges (they vary in number) in the main agree with the foregoing description, and occupy a distance conjointly of 2 mm. Considered as a whole in relation to their shape, position, and the muscle fibres, one is justified in considering these teeth as capable of mastication to some extent, and this is achieved, I believe, by the lateral faces of the teeth of the central fold working against similar teeth in the next parts of the ridge on each side, and so incision and crushing is brought about. Further, owing to their shape, and also to the aid of the setaceous projections, briefly mentioned, the finely triturated food is separated from coarse material, which is kept in the centre of the organ, and conveyed to longitudinal channels which run along the radial wall between the lateral folds, and become more pronounced towards the posterior. These I call food-pulp channels (Figs. 3 and 6, F.P.C.).

A transverse section, taken a little below the chitinous teeth, at the part marked 4 in Fig. 3, is shown in Fig. 6, the ridges of the six longitudinal columns, previously considered, will be seen to have changed in structure, they have no strong chitinous teeth, but the folds are covered by thin cuticle, clothed with fine setæ. The parts are not all alike, two, side by side, are similar to other two that are diametrically opposite, while the remaining two are quite different, but each is like the other, and they are situated opposite to each other. The food-pulp channels are here very conspicuous, and are seen to be guarded by projections and flaps, clothed with setæ, which act as guards to prevent the marc, or coarse food residue, which is kept in the centre of the gizzard, from gaining entrance to them. Tracing these food-pulp channels to the posterior outlet they are found to

turn into the cæca, and deflect upward for a short distance (Fig. 3). Six enter one cæcum and the remaining six the other.

The coarse food material is allowed to pass directly through the centre of the gizzard, but is prevented by four chitinous membraneous curtains (which hang down as far as the commencement of the fore-terminal canal), from gaining entrance to the cæcal organs, so that its delicate walls, which are unguarded by any chitin, are not injured.

Hepatic Cæca.

The hepatic cæca (mid-intestine) are two paired, oblong, and slightly concave organs, measuring 6 mm. through their long axis, and are situated one on each side of the gizzard, and in part attached to its wall (Figs. 1*a* and 3). The anterior of each terminates in a blunt point, a little more forward than the commencement of the gizzard and their posterior end stretches about 2 mm. behind the extremity of the gizzard. The wall lying next to the gizzard is concave, and this wall in each unites with the reflected hinder extremity of the gizzard, and the two cæca entirely surround it. The opposite lateral wall, that is the one of greater curvature, of each, extends posteriorly and joins the anterior extremity of the terminal intestine and entirely surrounds it; the remainder of the otherwise unattached walls of each, incurve, and unite with each other in the mid-axis, dorsally and ventrally.

In the lateral wall nearest the gizzard, the cellular layer forms two or more deep longitudinal folds, which project for some distance inwards, and enclose tracheæ. The internal surface area is consequently very considerably increased.

The histological structure is similar in each cæcum. There is no chitinous intima. The wall is sparingly supplied with radiating and transverse muscles, and next to these on the inner side is a thin layer of connective tissue, upon which are situated the cell elements. At close intervals, about ·1 mm., the connective layer projects slightly inwards, and between these projections are little chambers or nests, each with a rounded base. These are filled with cells which are supported in a fine reticulum, very apparent in a section cut across the cell nests (see Figs. 7 and 8).

Upon the projections of the connective tissue are long cylindrical epithelial cells with filamentous free border; they taper towards the attached end, and overarch the cell nests, leaving only a small opening, difficult to determine, which serves as a passage for the cells of the nests, or their secretions into the cavity of the organ.

The cell-nests are composed of young cells at the base, crowded together, which stain deeply; they gradually become matured towards the opening between the filamentous cells. I have considered the probability of these cell-nests being germinative centres containing young cells of the epithelium which overarches them, but their dissimilar appearance as they reach maturity, their greater number than the cylindrical cells, and also their position in relation to them, has convinced me of the improbability of such being the case.

The Terminal Canal.

This is joined to the posterior extremity of the cæca, and after describing several round turns in the body-cavity, ends at the anus. It is necessary on account of structural differences to divide it into fore-, mid-, hind-, terminal canal, and rectum. Except Cuénot, other writers have considered the mesodermal middle intestine to extend as far back as a little anterior to the entrance of the duct of the Malpighian vessels, and although this is so, I believe, in other of the Orthoptera, in Gryllotalpa there is no reason for so doing, for there is no marked differentiation of the cell-wall at this part. The musculature, however, changes sharply which gives an altered appearance from the outside. Further, the outer and inner muscle layers are both striated, which is not in accord with Professor Packard's description of the histology of the mid-intestine,[1] and there extends a chitinous intima throughout the whole of the passage.[2] The muscles surrounding the wall are reversed in order compared with the anterior canal, so that the longitudinal fibres are outside the annular muscles.

The Fore-Terminal Canal.

This is 4 mm. long, and is surrounded by a thick layer of annular muscles, with the exception of a small anterior portion.

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1 *Loc. cit.*, p. 316. 2 *Loc. cit.*, p. 302.

Its wall is thrown into deep longitudinal folds, and the lumen is capable of being closed.

At the anterior limit its wall forms a decided radial fold, projecting inwards as a ridge, after which it joins with the cæcal organs (Fig. 9).

As this junction is approached the cellular wall is free from muscles, and gradually widens like a funnel, and within this widened space the ends of the œsophageal valve lie.

The cuticle covers the cells from the commencement, and almost immediately is beset with short setæ, which point posteriorly, and continue as far as the mid-terminal canal.

At the posterior extremity, the strong bands of annular muscles cease, and the wall suddenly dilates to a width of about 1·5 mm., which marks the commencement of the mid-terminal canal. At the opening, loose folds of the wall of the fore-terminal canal project into the mid-terminal canal for a short distance, which act as valves to prevent a retrograde movement of the food material.

The Arborescent Organs of Dufour.

These are four very small bunches of minute dichotomously branching colourless tubes, forming a dorsal and ventral pair. An efferent duct from each bunch opens into the fore-terminal canal, on the anterior ridge just mentioned.

Cuénot has satisfied himself that they do not play any part in intestinal absorption, nor secrete any digestive fluid. He considers them to be excretory organs, eliminating a product made, doubtless, in a very small quantity. I venture to suggest that the product may be of use for the purpose of neutralizing the acid digested food residue from the cæca.

The Mid-terminal Canal.

This which is the "chylific stomach," ventriculus or mid-intestine of other authors measures 13–15 mm. in length, and its width at the commencement, when distended by food, is 1·5 mm., but it becomes gradually narrower as it unites with the hind-terminal canal. In its course it describes a full round turn in the body-cavity.

The cell wall is composed of a single layer of epithelial cells, and the tunica propria is surrounded by scattered radial and longitudinal muscle fibres. The general shape of the cells is columnar, but in parts they are cubical, and the whole internal face is covered by a very thin hyaline cuticle. The cell-wall frequently leaves the muscular bed and infolds transversely and longitudinally, thus forming little spaces where I have sometimes found "wandering" blood cells. Normally, the blood would always be present in these spaces, but unless entangled among the muscles or tracheæ, any cells would be lost in the preparation of sections.

On the ventral floor of the posterior two-thirds there is a fundamental change of structure; the epithelial cells are altogether wanting, and there exists only a thin nucleated structureless membrane, over which the cuticle lies. This area is much wrinkled, and here and there are short longitudinal folds, forming low ridges, which rise into the lumen, with spinous processes pointing posteriorly; also there are villi of varying length, which at first are few and scattered, but gradually become crowded together towards the narrower end of this part of the canal. These villi (Fig. 10) have the appearance of minute fox-tails, which stretch into the lumen; they vary in length somewhat, but generally are about ·25 mm. long. They are formed by ingrowth, or invagination of the chitinogenous layer, with the result that little hollow finger-shaped crypts or follicles are formed, into which the blood can enter. Each villus has several deep radial folds or pleats, with their anticlinal axis bordered with spinous processes which project into the cavity of the canal, and between these folds are consequently little furrows into which the digested food material can enter, but the granular material is prevented from so doing by the spinous guards.

However, I have not proved that they function in this manner. I have observed "wandering" blood cells in their cavity (Fig. 11), but whether they carry excretory products, or receive digested food, I am unable to definitely say.

The termination of the villous area marks the posterior limit of the mid-terminal canal.

Hind-Terminal Canal and Rectum.

These two, the first of which forms the hind-intestine of other authors, I will consider together. At its union with the mid-terminal canal the lumen becomes narrower, and the radiating and longitudinal muscles more numerous; they are separated at short distances, and the cell-wall between projects outwards to form little protuberances; the cells at these places are larger, and possess large granular nuclei. Viewed on the face, from the inner cavity, they appear as little caverns.

Towards the rectum the lumen widens, and a large cylindrical sac, 5 mm. long (the rectum), is formed, which becomes constricted towards the anus.

In this organ there are six definite longitudinal folds, lined with glandular cells, forming the so-called Rectal glands; they are transversely divided in places. The cuticle overlying these glands I have found to be fenestrated, the openings averaging ·075 mm. in diameter. About mid-way in the rectum there are four large caverns ranged radially round the wall, in which I have noticed, in fasting insects, large crystals adhering to the wall, which I take to be a nitrogenous salt that has crystallized out from material conveyed from the Malpighian tubes.

Malpighian Tubes.

These are fine, flexuous tubes about 14 mm. long, which ramify in the body-cavity. At their attached end they open into the dilated extremity of a common efferent canal (ureter) which, at a distance of 5 mm., enters close to the anterior extremity of the hind-terminal canal. As described and figured by Bordas, (1) the ureter at its junction with the canal protrudes for a short distançe to form a neck.

It was at first pointed out by Leydig that there are, in Gryllotalpa, two kinds of tubes, Yellow and White. The white tubes are very few in number, and are peculiar to Gryllotalpa; they are usually crammed with ovoid concretions of uric acid. The yellow tubes are very numerous, and their cells show within them little spherical yellow grains, and occasionally dark brown acicular crystals.

For description of these and other excretory organs, the valuable work of Cuénot (2) should be consulted.

Physiological Notes.

Perhaps no one has done so much experimental work to explain the functions of digestion and assimilation in insects as Plateau, and I regret not having had an opportunity of reading all his papers. I am indebted to the writings of Miall and Denny (3), and also to those of Cuénot (2), for summaries of his work, and to the latter for a resumé of the researches of other notable workers and of his own. It is generally accepted, I think, that the digestion of starch and sugar is effected in the crop by secretions from the salivary glands; that the secretions of the cells of the middle intestine, (those of the cæca playing a predominent part), transform the albuminoids into peptones, and also that fats are emulsified there.

I can find no proof that there is any secretion to split fats into fatty acids and glycerine outside the cells,

Difference of opinion exists as to where absorption and assimilation take place. Plateau and Jousset de Bellesme state that absorption takes place in the crop, the middle intestine, and even part of the terminal intestine. Cuénot (2) states that it is improbable, considering our present ideas on osmosis, that there can be the least absorption into the crop and terminal intestine, for both of them are covered by an impenetrable chitinous cuticle.[1] He further states that in the middle intestine alone and its diverticula, all the absorption is carried on, viz., that of the soluble products, peptones, glucose, and also fats.

For the purpose of determining this, I made some experiments, which prove that osmosis can take place, both in the chitinous lined crop and terminal canal.

To demonstrate this I employed the following methods:—

On three separate occasions I exposed the alimentary canal, and carefully ligatured it, 1st, at the commencement of the mid-terminal canal, and 2nd, at the posterior end, just anterior to the entrance of the ureter; also the œsophagus, at places, to close the passages to and from the crop. I then cut away the closed mid-terminal canal, and also the crop, and suspended them in a 5 per cent. solution of magnesii sulphas for two hours, after which, one at a time, they were thoroughly washed in three separate basins of

[1] *Loc. cit.*, p. 306.

distilled water, opened, and the contents of each placed in watch-glasses (the organs being discarded), distilled water added, then filtered, and the filtrate evaporated, and examined microscopically for amount of crystals, and also chemically tested. The result of each examination was the finding of an amount of magnesia sufficient to prove that osmosis had taken place. The third basin of water used for the final washing of the organs was chemically tested, without showing any appreciable amount of magnesia.

My conclusion regarding the digestion and assimilation of Gryllotalpa, based upon the experimental work of others, and my own, both physically and structurally, is :—

1. That the salivary glands secrete an amylolytic and inversive ferment, which mixes with the food in the crop (Plateau) and that absorption of the glucose can take place in that organ by the epithelial cells, which pass it on to the blood. (Vide experimental proof ante).
2. After a longer or shorter time the food is passed on and enters the gizzard, where it is squeezed, and probably to some extent masticated. In the squeezing the pulp is collected in the open food-pulp channels, which convey it into the cæca ; the coarse residue passing on to the hind-terminal canal.
3. In the cæca the food-pulp is acted upon by secretions of the cells of the cell-nests, which rapidly disintegrate in the work. The fats are emulsified, and a proteolytic ferment transforms the albuminoids into peptones. The filamentous cells take up the emulsified fats, and split them into fatty acids and glycerine within themselves, to be passed on to the blood cells which carry them away, and any excess over immediate requirement is stored up probably in the fat bodies (Cuénot). Other material may also be taken up by these eminently absorbing cells.
4. The remaining digested food passes into the fore-terminal canal, and then into the mid-terminal canal, where it mixes with the coarse food material

and remains for a long time. (In fasting insects after two months, and may be longer, I have found food material there and numberless bacteria). The required soluble products are then selected and absorbed by the epithelial cells, to be passed on to the blood plasma, the setaceous villi and folds playing a large part in gathering what would otherwise escape, while the blood cells within the crypts may absorb, assimilate and transfer the products to other parts.

5. The insoluble residue passes on to the rectum, where mucus, secreted by the cells of the longitudinal rectal glands, is mixed with it and the contents ejected. When an insect is alarmed the black viscid contents of the rectum are ejected with considerable force to serve in defence. The bacteria, which always exist in large numbers in the mid-terminal canal, may render important service in the breaking up of albuminoids, proteids and fats, which have escaped digestion in the mid-intestine (cæca).

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2. Cuénot.—Etudes physiologiques des Orthoptères Arch. Biologie, t. xiv., 1896, pp. 293–341.
3. Miall and Denny.—The structure and life-history of the Cockroach. London 1886.

For full lists of literature see the valuable text-book of Entomology by Prof. A. S. Packard (Macmillan), 1898.

EXPLANATION OF PLATES.

Note.—With the exception of Figs. 1 and 1*a*, all the Figures have been outlined under a camera lucida.

Fig. 1.—Semi-diagrammatic view of the enteric system of Gryllotalpa australis (Erich.), dissected from the left side, and showing positions of the various

organs in respect to the exoskeleton. × 3. A anus; C.A. one of the cæcal organs; the proventriculus and other cæcum are hidden (see Fig. 1*a*); C.R. crop distended; F.T.C. fore-terminal canal, joining anteriorly with the cæca and posteriorly with M.T.C. the mid-terminal canal; L. lingua (hypopharynx); L.L. labium; L.P. palpus labii; M. mandible; M.P. palpus maxillæ; M.T.C. mid-terminal canal, ending a little anterior to the entrance of the duct of the Malpighian tubes; M.V. Malpighian tubes, only a small number shown, there are two kinds, white and yellow; $O.E.^1$ fore-gullet; $O.E.^2$ hind-gullet; R. rectum; R.C. rectal glands; $S.D.^1$ common duct of salivary glands; $S.D.^2$ indicates the junction of the right and left median salivary ducts, that leading from the left-side is cut off a little lower down:—S.R. one of the salivary receptacles; U ureter; U.L. labrum.

Fig. 1*a*.—Proventriculus and cæca viewed from ventral aspect × 3. A.O. arborescent organs of Dufour (only the ventral pair shown); C.A. cæca; they compose the whole of the middle intestine (mesenteron); G. proventriculus (gizzard).

Fig. 2.—Longitudinal section of wall of fore-gullet × 650. A radial muscle fibres cut across; B longitudinal muscle fibres; C epithelium cell of hypodermis; D chitinous intima bordered by teeth which are acutely bent and point behind, seen with their thin edge uppermost.

Fig. 2*a*.—An isolated tooth of above with its broad surface uppermost × 650.

Fig. 3.—Median longitudinal section through the proventriculus and mesenteron × 11. C.O. cæcal organs; F.P.C. a food-pulp channel entering into cæca; F.T.I. fore-terminal intestine; F.L. a longitudinal infold of the cæcum cut through the face of cells; O.V. Œsophageal valve—two flaps only show cut

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through. 1. Marks the junction of stomodæum with mesenteron. 2. Marks the junction of proctodæum with mesenteron.

Fig. 4.—Part of a transverse section of the proventriculus, at position marked 3 in Fig. 3, showing a transverse section of one of six similar longitudinal columns. The section has been cut between two radial ridges, and shows the anterior or upper surface of one-sixth part of a ridge; each part is similar; × 90. P. junction of one part with the next corresponding part of a radial ridge; L.T. lateral tooth; M.T. median tooth; M.T.A. median tooth extension.

Fig. 5.—Summit of left hand lateral tooth and also of median tooth extension, viewed from the side and somewhat underneath × 320.

Fig. 6.—Transverse section of proventriculus at position marked 4 Fig. 3 × 90; F.P.C. a food-pulp channel cut across; T. tracheæ; P. similar part to P. in Fig. 4.

Fig. 7.—Section of wall of cæca, Rabl's fix. Safranin × 310; C.N. a cell-nest; C.T.B. connective tissue bed; M.F. outer muscle fibre; S.C. epithelial cells with filamentous border.

Fig. 8.—Section of wall of cæca at position marked 1 in Fig. 7, showing cell-nests cut across with reticulum. Most of the cells have been displaced, only a few nuclei to be seen × 310.

Fig. 9—Junction of mesenteron with fore-terminal canal (proctodæum) × 70; C.C. point of origin of chitinous cuticle, which, at a near distance becomes setose.

Fig. 10.—An intestinal villus pointing into the lumen; situated on ventral floor of mid-term. canal. After maceration in caustic potash solution × 320.

Fig. 11.—Oblique section of a similar villus to Fig. 10, showing three blood cells in the crypt. Rabl's fix. Hæmatox. oil im. × 680.

ART. VII.—*On the Structure of the Vibratile Tags or Flame Cell in Rotifera.*

By J. SHEPHARD.

(Plates XI. and XII.).

[Read 11th August, 1898.]

The somewhat doubtful tone of the remarks on the flame cell or vibratile tags of Rotifera in the second volume of the "Cambridge Natural History" led me to examine these organs in *Euchlanis dilatata* and *Brachionus pala*, species favourable to a study of the excretory system, particularly the former. Having these two forms at hand in a cultivation from dried mud, for a considerable time, there was ample opportunity to examine them, and as a result a definite conception of the structure of the organ was attained, and, being subsequently confirmed by investigations on several species, I was led to record my results in the hope of contributing towards a settlement of the vexed question as to their exact structure.

The flame cells are appendages of the lateral canals which run up each side of the body, and are regarded as the excretory organs in the Rotifera.

The outlines of the tags examined, in different aspects I found in general agreement with the description by Dr. Hartog[1] and with the descriptions and figures of various other authors. In front view the outline is more or less fan shaped, and at right angles to this it has a narrow elongated form very nearly equal in width from end to end. In the internal portions of the tags I found appearances not altogether consistent with any of the figures and descriptions to which I have had access.

Examining a specimen of *E. dilatata* when compressed so that the tags were fixed, some of them were found presenting the narrow and others the fan-like aspect. When seen in the former position, a solid plug occupied the distal end, and to it, as shown

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1 Cambridge Nat. Hist., vol. ii., p. 213.

in all the figures given, was attached what appeared as a solid and, as compared with the walls on either side, a thick flagellum, extending nearly to the point of attachment of the tag to the lateral canal, and down this apparent flagellum ran a series of undulations commencing at the attached end of the movable body and passing along to its free end.

Those in the flat aspect showed the plug at the distal end as a border of protoplasm running across; it was spongy looking, occasionally vesiculated, and with little protuberances on the outside, generally looking denser just at the point of attachment to the undulating body, and in appearance analogous to the substance of the walls of the lateral canals. As in the narrow aspect, the sides were excessively thin. Indeed in a dead animal the whole appearance was that of a hyaline fan-shaped cavity, the boundaries of which required most careful focussing to define. In a living and vigorous animal, the flickering appearance which has given rise to the term "flame cell," was very rapid, and it was difficult to determine the exact nature of the movement going on, but in animals treated with cocaine, or losing vigor through long confinement, the movement could be distinctly seen as a series of waves in some substance lying between the upper and lower surface of the tag. Through this moving substance could be focussed, and kept steadily in view, two distinctly longitudinally striated surfaces. Repeated observations on cells in various states of activity, confirmed the conclusion that these striations are on the walls of the tag and not on the undulating body. Further, the most careful scrutiny failed to show any lateral borders to the moving body other than the sides of the tag itself.

In a recently killed animal the undulatory movement could be seen to die down until it was a slight wave-like appearance, gradually narrowing until it occupied the median portion of the tag, and dying out before passing more than half way down, just as a ripple on water dies away as it recedes from the point of disturbance. Another appearance obtained from some chance views of a tag when the free end was pointing up the microscope, is shewn in Fig. 3. Here was presented an optical section showing a flattened oval with thin walls and a thicker line running between and joining the extremities.

From these appearances I conclude the tag to consist of a flattened funnel closed at one end by a protoplasmic mass, to which is attached an "undulating membrane" lying between two thin, delicately striated walls, to which it is joined on each side for its whole length, being free only at the narrow proximal end of the tag, and dividing the interior of the tag into two separate cavities or pockets.

In the references which I have been able to make to the literature of the subject, I find considerable disagreement as to the nature of the internal structure Dr. Hartog[1] states, that: "The probable explanation of the two distinct wave appearances within the tag is that the protoplasmic plug bears on its inner face a row or tuft of long cilia hanging down into the cavity of the tag." Dr. Zelinka figures and describes[2] the vibratile tag of *Callidina russeola* as containing a cylindrical mass of closely agglutinated cilia, and estimates the number of such vibratory hairs. He also quotes Mœbius as having recognised the composition of the flagellum from numerous cilia. He further gives an abstract of a description of the vibratile tags in *Asplanchna amphora* by Mr. C. Rousselet, who definitely regards the vibrating structure as an "undulating membrane," and suggests that the spongy protoplasmic cap is "probably quite open enough to allow some part of the fluid of the body cavity to pass through into the tags." Dr. Hudson[3] asks "Are the vibratile tags open at their free ends or are they closed. Do they contain an undulating membrane, or are their inner surfaces furred with minute cilia?" Dr. Weber[4] describes the tags of *Hydatina senta* as a flattened bell, with a cleft at the upper part surrounded by a pad armed with short cilia, while below are two thickenings each furnished with a long cilium. He figures these cilia with undulations crossing each other. He also states that all the

1 Cambridge Nat. Hist., vol. ii., p. 213.
2 Zeit. fur Wiss. Zool., vol. liii., p. 22.
3 The Rotifera, vol. ii. Appendix, p. 137.
4 Notes sur quelques Rotateurs des Environs de Genéve, p. 39.

flame cells he has examined are of similar structure Vallentin[1] gives a figure of the flame cell of *Brachionus rubens* obtained by the section method showing a thin wall with a broad flagellum hanging from the cap.

In the face of these statements by observers of such eminence I advance my views with diffidence. However, as repeated examination of many individuals of *B. pala* and *E dilatata* and observations of a less number of each of the other species figured, as well as others not figured, such as Anurea sp., *Synchæta pectinata*, *Notops brachionus*, and *Pterodina patina* all combine to corroborate the view I take, the record of these observations may be of service.

With the exception of Dr. Weber, none of the observers mentioned appear to have noted the striated nature of the walls of the tag. This he regards as due to a fine muscular network. I suggest that the conclusion as to the undulatory body being a number of waving cilia has arisen through these striations being perceived through the undulating membrane, and being confused with it. Indeed at first sight it seems obvious that cilia are present. I have already mentioned how flame cells of reduced activity show distinctly that the striation is on the walls and further that the undulating membrane is very transparent, in fact it can only be distinguished in the flat aspect by the interference with the light due to its movement. In dead animals it cannot be seen in the flat. Vallentin's figure above mentioned appears in the light of my observations as a longitudinal section taken somewhat obliquely. Without dealing separately with all the views quoted I suggest that they are all possibly due to the differing appreciations of this combination of an undulatory hyaline membrane and two striated walls which themselves in the living animal are in constant movement. Mr. Rousselet's views are of course excepted, and I regret being unable to procure a copy of his paper, more particularly as I have fortunately met with *Asplanchna amphora* and find the structure to coincide with the description so far as it is given by Zelinka. I have in vain endeavoured to procure a copy of this paper and of course am unaware as to how far my

[1] Ann. and Mag. of Nat. Hist. Ser. 6, vol. viii., p. 44.

work may overlap that of Mr. Rousselet. Having arrived at a similar conclusion with regard to the undulating membrane before knowing his view and having figured a similar structure in five species it will corroborate this portion of his observations and extend it to other families. The two flagella on the outside of the tag as mentioned by him were undoubtedly present. It does not, however, appear to be necessary to assume that the spongy looking protoplasmic cap permits the passage of fluid from the body cavity into the tag as he suggests. Rather are not the thin walls instrumental in passing by osmosis the excretory fluids. From this point of view the fan-like expansion of the tag is to be explained as affording a larger surface area. Comparing the areas available for this, taking the narrow line of the caps on the one hand and the two flat sides on the other in *Asplanchnopus myrmeleo*, we should get, taking the thickness of the tag as $\frac{1}{8}$th of its breadth and other dimensions as measured, areas in the proportion of about 11 to 1. That the fluid excreted is considerable is shown by the fact that in *A. myrmeleo* the contractile vesicle when expanded occupies about $\frac{1}{8}$th of the body cavity and contracts at intervals of a few seconds. I counted 50 tags on one side making 100 in all. Assuming that the fluid passes through the sides, the organ in this view become an admirably adapted force pump to drive the fluid into the canals, the swing causing the crests of the undulations in the membrane to come in contact with the wall on either side. Further if flagella are in action internally they would be required to propel the fluid in the direction of their free ends, whereas in the collared and other Protozoa the action of the flagellum is to cause a current inward to the base.

Of the forms examined I refer to the accompanying figures without further comment excepting those of the tags of *A. myrmeleo* which have not to my knowledge been described. There are also some additional features of interest. Fig. 9 is a portion of a canal with tags at (*a*), (*b*) and (*c*) in narrow aspect and (*d*) in the flat. In this form there is one external flagellum about as long as the whole cell seen in the middle from the flat view and to one side side in the narrow aspect. Some cells, one shown in two aspects in fig. 12 and 13 attached to the convoluted portion of the duct at the posterior of the animal appear destitute

of flagella and to have the protoplasmic cap expanded into a vesicle. They appeared less flattened. Other cells such as Figs. 10 and 11 possessed lesser vesicles in the cap and flagella in conjunction.

The whole of the figures were drawn from a magnification of about 1000 dia. using a Leitz $\frac{1}{10}$th semi-apochromatic oil immersion lens, and a Watson & Son's parachromatic condenser. Rigid adherence to the conditions necessary to produce a "critical image" was found necessary, and all observations were made in a flame image, daylight being unequal to bringing out the finer details.

I have to express my thanks to Professor Spencer for procuring me the literature, and to Mr. W. Stickland for assistance in reading the German and French Papers.

EXPLANATION OF FIGURES.

Euchlanis dilatata.

Fig. 1.—Flat view of tag

„ 2.—Edge view of tag. Dimensions, length ·013 mm.; breadth ·007 mm.

„ 3.—Optical section of tag seen end on (*a*) striated surfaces.

„ 4.—Portion of lateral canal.

Brachionus pala.

„ 5.—Flat view of tag.

„ 6.—Edge view of tag. Length ·012 mm.

Hydatina senta.

„ 7.—Flat view of tag.

„ 8.—Edge view of tag. Length ·014 mm.; breadth ·01 mm.

Asplanchnopus myrmeleo.

„ 9.—Portion of lateral canals with tags attached in edge view (*a*), (*b*), (*c*), and flat view (*d*). Length of tag ·009 mm.; breadth ·004.

„ 10.—Flat view of tag with vesicle in cap and flagellum.

Fig. 11.—Flat view of tag with large vesicle in cap and flagellum.
„ 12.—Flat view of tag with large vesicle and no flagellum.
„ 13.—Edge view of tag with large vesicle and no flagellum.

Asplanchna amphora.

„ 14.—Flat view of tag.
„ 15.—Edge view of tag. Length ·01 mm.; breadth ·004 mm.

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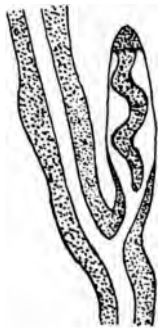

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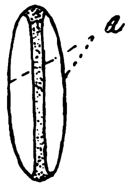

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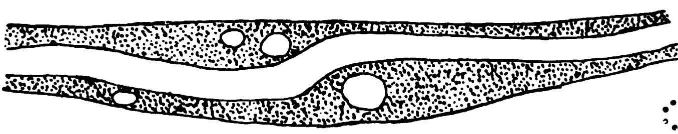

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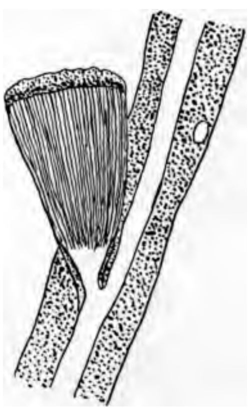

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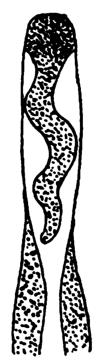

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Writing in 1872 L. Koch described two species of spiders from the Philippine Islands and Borneo, for which he created the genus Nephilengys at the same time upbraiding his friend the celebrated arachnologist the Rev. O. P. Cambridge, for having included in the genus Nephila, Leach, a spider from the island of "Taprobane," named by him *N. rivulata* but which, as L. Koch felt, differed too markedly from the type of this genus to be possibly included and which belonged to the type of his Nephilengys. A fourth species from the Malabar Coast placed by Walckenaer in his genus Epeira completed the list of those known to L. Koch.

In publishing the "Australian Spiders" he utilised the opportunity to describe the two above-noted species, and to bring forward his new genus, in the anticipation that through its connection, by chains of islands, to the Philippine group, some species might be found on the Australian continent.

In looking over Professor Spencer's specimens I find two females, superficially somewhat like Argiope, which prove, on examination, to have marked characteristics of each of the genera Nephila, Herennia, Argiope, and Gea (Ebœa, L. Koch), genera which, all allied, form successive groups of M. Eugene Simon's adjacent sub-families Nephilinæ and Argiopinæ.

They seem to me, however clearly, not confined within the bounds of any one of these groups, and I had decided on a new genus for them, when I was struck with their conformity with L. Koch's above-mentioned genus, combined with his anticipation that it would possibly be found in Australia.

The genus was clearly made for them, and they might be its type form.

They now turn up, twenty-five years afterwards, in one of his best searched hunting grounds.

M. Simon, in his splendid work "Histoire Naturelle des Araignées" now being published, puts the genus back into Nephila. His argument that it runs into Nephila would equally serve for connecting through this species all the genera from Nephila to certainly Gea, and perhaps Epeira (Araneus, E. Simon).

The side eyes, besides being nearly as wide apart ($2\frac{1}{2}$ diams.) as the front and rear median, approach the latter almost as closely as the median themselves lie from one another.

The epigyne is a distinctly advanced development on the Nephila type, and the metatarsal joint of all legs just equals in length the patella cum tibia.

The cephalothorax has also progressed (or retrograded), from Nephila towards Argiope and Gea.

The genus seems to lie between Herennia and Gea in much the same manner as M. Simon points out that Herennia does between Nephila and Argiope.

We have some nice specimens of L. Koch's *Epeira producta* and *Epeira capitalis*, showing not only the variations described by him in the former, one of which brings it close up to *E. capitalis*, but that the latter which really only differs in the pattern of the back of the abdomen, is no more than a variety, at most, of the former species. Koch makes the front middle and rear middle eyes of *E. producta* almost equal in size, while in *E. capitalis* the front middle are larger than the rear middle eyes.

It was this peculiarity that induced me (in spiders of the Horn Expedition) to make a new species of *Epeira frostii*, which is very close to *E. producta*, but has the front middle eyes largest. Including these specimens of Professor Spencer's, which in other respects all agree exactly with *E. producta*, I have never seen one which has not had the front middle eyes larger than the rear, and I am inclined to think that Koch may have accidentally exaggerated this point, and that the whole three species are, at most, local varieties of the same.

The only other difference noted by Koch is that in *E. producta*, the stylus of the epigyne is dilated in the middle, whereas, in *E. capitalis* it is not. I do not find this difference to hold good as, although more often dilated than not, it is indifferently the same in both species; both in length, when full-grown, and in the remainder of the chitinous placque there is absolutely no difference whatever. The pectinations, falx teeth, and other small points are the same in both species.

One peculiar feature I notice in the largest of these *Epeira capitalis* is a development of one of the bristles which meet the claws from the inner side, at the end of the tarsal joint of the first and second pairs of legs.

The corresponding bristle on the outer side is very stout and horny at the base, from which it tapers sinuously to the point,

with six pectinations along the middle, but the inner side one is flattened and dilated in the middle almost into the shape of a leaf with numerous small scollop like pectinations all along the outer edge, and a curved claw at the end.

The second new species belongs to the curious genus Poltys, C. Koch, in M. Simon's group Poltyeæ, one of his many divisions of his sub-family Argiopinæ—one of the peculiarities of these spiders is that six of the eyes stand on a little head of its own joined by a neck to the rest of the cephalothorax while two other eyes are set a long way off on the main cephalic part.

Their most striking feature, however, is the development of warty prominences on the abdomen which has the appearance of just growing by chance in every direction and the more species you examine the less do they seem to be guided by any regular law in their remarkable growth.

I have not seen sufficient material to know how far the projections are persistent in the same species, but they are not quite regular even in the same individual. Among the Cyrtarachne I have noticed specimens where, though identical in every other respect, normal abdominal prominences of a very decided type were entirely absent, and it would seem as if these wart-like projections were among the latest developments of the species.

A male Nephila has unfortunately lost both palpi and legs except No. III. on one side—it is most like *N. sulphurosa*, L. Koch.

We experience great difficulty in obtaining evidence connecting the males and females in this geuus, in which the size and appearance of the sexes differs so materially, and much more field work is required in the generally sparsely inhabited districts in which they are most abundant before they can be allotted with certainty.

I trust that as time goes on we may be favoured with many more specimens from this apparently rich district.

I append detailed descriptions of the two new species which I have ventured to name *Nephilengys rainbowi* and *Poltys frenchi*, after my friends and fellow-workers Mr. W. J. Rainbow of the Australian Museum, Sydney, and Mr. C. French, Government Entomologist of Victoria.

Nephilengys rainbowi, nov. sp.

Colour.

Cephalothorax.—Bright chestnut on cephalic part. Eye space black brown. A longitudinal yellow streak from front to rear of thoracic part, remainder dark red-brown with grey hairs.

Mandibles and Maxillæ.—Black-brown, fangs of former and edge of latter red-brown. *Lip*, paler brown. All with upstanding dark brown hairs.

Sternum.—At sides and transversely across the middle black-brown, and upper and lower portions yellowish-grey.

Coxæ.—Yellow transverse stripe between two black ends.

Abdomen.—Above mottled with dark and light brown patches, fine pale recumbent pale greyish-brown hairs; below greyish-brown mottled with dark brown. A larger dark brown patch in front of spinnerets, which with epigyne are black-brown. Sides dark brown, with three backward curving paler stripes reaching from back to underneath. Very fine recumbent pale brown hair.

Palpi.—Yellow on femoral joint changing to dark red-brown in tibial and tarsal with upstanding black-brown hairs bristles and spines.

Legs.—Yellow to red-brown, darker on tarsus and metatarsus and on anterior end of the other joints forming on underside nearly black patches.

Shape.

Cephalothorax.—Low on thoracic, raised and convex on cephalic part, a deep transverse fovea separating the two. In middle of former a deep transverse oval dimple. The cephalic part set with short thick spines.

The clypeus recedent, in the centre as wide as front middle eyes. The four middle *eyes* form a rectangle slightly longer than broad. Front eyes largest, their diameter apart, and 1½ diameters from front side eyes. The rear middle eyes are smaller two of their diameters apart, and same distance from front pair, three diameters from rear side eyes. The side eyes are smaller than the rear middle, set on an oblique tubercle, and are slightly nearer together than front and rear middle, being 2½ of their own diameters apart. Both rows slightly recurved.

Mandibles.—Knee-formed at base. Longer than Patella I., and thicker than femur I. Smooth, with short black bristles on upper part. Three teeth on each edge of falx sheath, the middle one much the larger; fangs stout and well curved.

Maxillæ.—As broad as long, truncate at top. *Lip* square from bottom edge to top of sides whence it goes into a point. This upper triangle being divided by a suture from the lower square.

Sternum.—Long shield shape, flat with low prominences pushing forward the two upper corners, and two more down each side. The posterior end slightly separates the fourth pair of coxæ, but does not pass more than half way between them.

The Abdomen is high, longer than broad, rounded in front and at the sides, running into a point at the rear. The Epigyne is transversely oval formed of two sinuous chitinous plates meeting in the middle. It is situated on a raised fold, and forward of it is a small oval bare depression.

The *Palpi* are as long as the Cephalothorax, the femoral joint curved inwards and thickened at the anterior extremity. Patellar and Tibial together shorter than tarsal joint.

Legs.—Long, rather fine, smooth on upper joints with regularly laid fine short hairs and short curved spines. The metatarsal joint equals in length the patella cum tibia on all legs. The lower tarsal claw bears two very short teeth near the base, the upper five fairly long teeth, of two specimens, both females, one is much lighter on the abdomen but darker on the cephalothorax and legs than the other.

MEASUREMENTS (IN MILLIMETRES).

	Length.	Breadth.
Cephalothorax	7	3½ in front. 4 in widest part.
Abdomen	10	6½

		Coxa	Tr. and femor.	Pab. and Tib.	Tars. and metab.	Total length.
Legs	1	2	9	8½	10½	= 30
	2	2	8	7	9	= 26
	3	2	6	4½	6	= 18½
	4	2	7	7	9	= 25
Palpi	—	—	3	1¾	2¼	= 7

Relative length of legs, 1, 2, 4, 3.

This species is much smaller than *H. schmeltzii*, L.K., from the Philippine Islands, its legs not so continuously ringed. The underside of abdomen less distinctly marked and the epigyne more complex. The maxillæ do not reach so far down the lip posteriorly, otherwise the two seem very similar.

Though nearer in size to *N. hofmanni*, L.K., from Borneo, it differs from it in much the same points as the above. In *hofmanni* also the epigyne is less differentiated and the metatarsal joints seem longer in proportion than in these species.

Poltys frenchi, nov. sp.

Colour.

Cephalothorax.—Pale to darker orange-yellow, being lightest on the thoracic part just behind the cephalic and deepening into red-brown on the eye prominence, a pale narrow band borders the edge of the pass thoracic. The scanty hairing is quite pale yellow.

The *Mandibles* are a dark orange on the upper half, shaded into red-brown on the lower, the former part having long stiff pale yellow-grey hairs, the latter thin brown, the fangs black-brown at base, lighter into red towards the points.

The *Maxillæ* and *Lip* are a dirty yellow-grey with grey edgings and a silver-grey fringe.

Sternum.—Black-brown, with black hairs.

Palpi.—Yellow-brown, darker brown on tibial joint. Tarsal joint thickly covered with long pale yellow hair.

Legs.—Red-brown from coxa to metatarsus, tarsus golden-brown, with pale drab hair and bristles, and reddish-orange spines. The end of the femoral and the patellar joint are dark brown.

The *Abdomen* is of a dirty darker and lighter brownish-grey covered with silvery-grey hairs. In front a dark transverse curved stripe above the juncture with the cephalothorax and an oblong black and white spot in the centre beyond same. Behind, a darker stripe stretches down the middle hollow of the back and in the hollow between the warty prominences. The underside of the abdomen below the juncture with the cephalothorax is darkest at the sides with a paler central longitudinal streak. Epigyne and spinnerets dark red-brown.

Shape.

The *Cephalothorax* is ·001 longer than broad, a deep fovea curving forward separates the cephalic part from the thoracic, the latter being separately very convex steeply sloping to the edge all round, a dark coloured median stripe leads from its front edge to a deep circular depression at the top of the rear slope. The cephalic part is also strongly convex within its own borders and higher than the thoracic, rising from the dividing suture. Just above the base of the palpi it is constricted but slightly widens again with circular curves to the front centre from which a tubercle bearing six of the eyes stands out on a somewhat narrowed neck. The two rear side eyes, when viewed from above stand far back on the main body of the pass cephalica, near the edge, in front of the constriction, and are about as far apart as their distance from the top front eyes on the tubercle. The rear eyes and the four on the top of the tubercle are equal in size, the lower pair in front of the tubercle being one and half times the diameter of the others. The top front eyes on the tubercle are two diameters apart and the same distance from the hinder pair also on top of tubercle. They are each of them one diameter from the lower larger eye on the same side of the tubercle as themselves.

The *Mandibles* are not so thick as the front femur and shorter than patella of same—they are conical, only slightly bowed, parallel on the outer side, and divergent in the lower half of the inner side. The fangs short and well curved, three teeth on outer falx edge, the lower quite small, two teeth on inner edge.

The *Maxillæ* are broad as long, truncate at top, inner edges parallel, the outer sides curving regularly to a small base level with bottom of *Lip*, which is broader than long, pointed at top, and less than half the length of the maxillæ.

The *Sternum* is flat, broadly cordate, sparsely covered with long thin upstanding hair.

The *Abdomen* looked at sideways stands upright at right angles with the cephalothorax with which it is joined at about one-third of its height. It is here at its greatest thickness and curves about equally at back and front down to the spinnerets, where it ends in a point. Upwards from point of juncture with

the cephalothorax it again curves inwards to a point, where a cubical shaped turret, divided into four at the top, stands pointing obliquely outwards.

The back view shows an inverted isosceles triangle, the turrets being at the base angles with an inverted saddle between them, and the spinnerets at the apex. On each side are placed two pairs of small conical prominences, one pair just below each turret and the other pair half way down on a level with the junction of the cephalothorax.

Viewed from front the turrets stand out obliquely with a conical prominence in the hollow between them flanked on each side by a smaller one. The upper pair of hinder prominences show out laterally.

The epigyne consists of a stout square transversely wrinkled plate lying on the body and supporting as a mid-rib a triangular broader follicle which stands out from the surface.

In the *Palpi* the femoral joint is curved to the head and thickened at the fore-end, the tarsal joint longer than tibial, and both are thickly covered with bristly hair and spines.

The *Legs* have the femoral joint stout, dilated in the middle and curved on the outer edge, the other joints tapering to a fine point on the tarsus. The femurs and patellæ are nearly bare, but the tibia tarsus and metatarsus are armed with long spines and thickly covered with stout upstanding bristly hair. On tibia and metatarsus I. and II. a closely lying double row of short curved spines on inner side gives the appearance of a magnified calamistrum.

MEASUREMENTS (IN MILLIMETRES).

	Long.	Broad.	High.
Cephalathorax	5	4	—
Abdomen	5½	8½	10½

		Coxa.	Tr. and Femur.	Pal and Tib.	Metat. and Tars.	
Legs	1	1½	6	6	4½	= 18
	2	1½	5½	5½	4	= 16½
	3	1½	3½	2½	2½	= 11
	4	1½	5½	5½	4	= 16½

Relative length of legs, 1, 2, 4, 3.

This species is a good deal larger than *P. laciniosus* to which it seems nearer than any other recorded. The prominences and colouring differ entirely both from that and its congener *P. mammeatus.*

Locality.—Upper Endeavour River, Queensland. One female only.

DESCRIPTION OF PLATE XIII.

Nephiliengys rainbowi.

Fig. 1.—Dorsal view. Life size.
Fig. 1*a.*—Eyes.
Fig. 1*b.*—Lip and maxillæ.
Fig. 1*c.*—Epigyne.
Fig. 1*d.*—Tarsal claws.

Poltys frenchi.

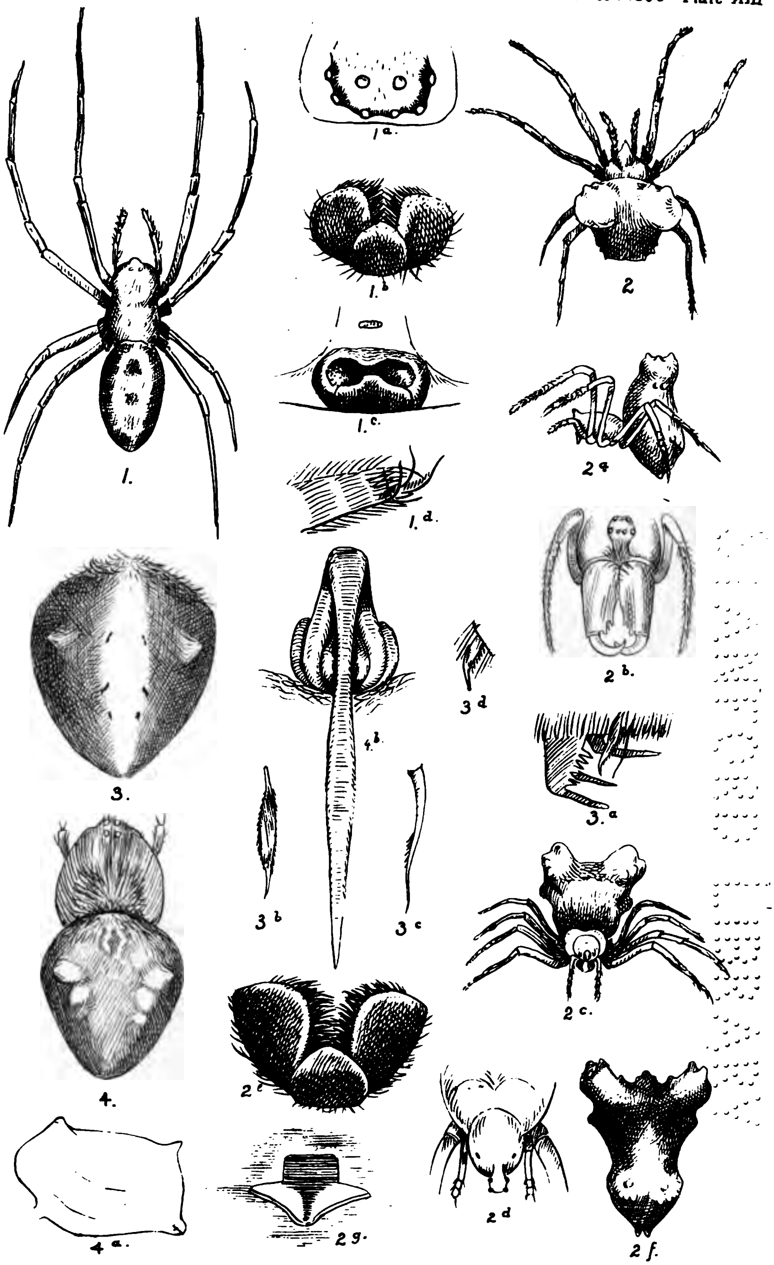
Fig. 2.—Dorsal view.
Fig. 2*a.*—Side view.
Fig. 2*b.*—Head, seen from in front.
Fig. 2*c.*—Front view.
Fig. 2*d.*—Head from above.
Fig. 2*e.*—Lip and maxilla.
Fig. 2*f.*—Rear view of abdomen.
Fig. 2*g.*—Epigyne.

Epeira capitalis.

Fig. 3.—Abdomen of *Epeira capitalis.*
Fig. 3*a.*—Tarsal claws of the same.
Fig. 3*b.*—Spine on the inner side of the foot of the same.
Fig. 3*c.*—Spine on the outer side of the foot of the same.
Fig. 3*d.*—Palp claw of the same.

Epeira producta.

Fig. 4.—Abdomen and Cephalothorax of *Epeira producta.*
Fig. 4*a.*—Side view of abdomen of the same.
Fig. 4*b.*—Epigyne of *E. capitalis* and *E. produtca.*



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Art. IX.—*Notes on the solubility of Gold-Silver Alloys in Cyanide of Potassium Solutions.*

By DONALD CLARK, B.C.E.

[Read 8th September, 1898.]

Some experiments were undertaken with the assistance of Messrs. Johnson and Osborne, students at the School, in order to determine the solubility of gold and silver alloys in potassium cyanide solutions.

Since pure gold never occurs in nature, and I have never met an alloy containing less than 60 per cent. of gold and 40 per cent. of silver, a series of alloys containing from 60 to 95 per cent. of gold was prepared for solution.

Gold cornets, which contain only a trace of silver, were taken and melted with the amount of pure silver required to make the given alloy. These were then rolled out and annealed, and strips were cut off and carefully weighed. The strips measured 1 inch in length and $\frac{1}{8}$ of an inch in width, and since they weighed about two grains, their thickness would be $\frac{1}{300}$ of an inch.

Small bulbs were blown on glass tubes, and a pin hole made in each bulb; into one of these each metallic strip was inserted and the whole were immersed in an inverted bell jar containing a ·25 per cent. solution of potassium cyanide, the liquid was kept several inches above the gold and was allowed to slowly drop through the stopper of the jar, thus ensuring a constant and fresh supply of cyanide for the gold. It was intended to have dissolved each of the strips completely, but it was found that after 597 hours' contact that the gold had commenced to separate out in fine flakes, and that several of the strips were eaten through, so it was decided to assay the undissolved alloy in order to find if its composition remained unaltered. The temperature of the laboratory during the time of experiment varied from 35°F. to 65°F.

Experiments were also tried on strips cut from the same alloys with the same solvent, only in this case the strips were placed in large test tubes and not disturbed. The action, as might be expected, was slower.

Next, the same series of alloys were used to test the solubility of gold in chlorine solutions.

A number of tubes were connected and partly filled with chlorine water—strips were placed in each tube and a slow stream of chlorine allowed to pass through them in a dark chamber for 90 hours. The strips were then washed with water, then with ammonia water until the chloride of silver which had encrusted the surface had dissolved; these were then dried and weighed.

A solution containing ·1 per cent. of chlorine was allowed to remain in contact with another series of strips for 304 hours, but the action was exceedingly slow.

It will be seen from the results of these experiments, that an alloy containing 95 per cent. of gold is dissolved more readily than pure gold or than alloys having a greater percentage of silver.

Further, that these alloys are not dissolved regularly and evenly, but that in some cases the action of the solvent is slower at first and more rapid after some time: since a crystalline surface was developed on those placed in the cyanide solution this may be due to rather a definite compound being more rapidly dissolved or the material between the crystals being attacked and thus allowing the crystals to stand out in relief.

It will also be seen that those alloys approaching the formula Au. Ag. are more evenly dissolved than those differing widely from that formula, the latter having a higher ratio of silver after partial solution, while the former are practically unchanged.

The circulating solution dissolved more gold in the same time than the fixed solutions.

In the case of the saturated chlorine solution the action was exceedingly rapid as compared with the cyanide, but even after 90 hours' contact only from 50 to 85 per cent. of the strips was dissolved.

In the case of the ·1 per cent. solution of chlorine the action was so slow that in 304 hours only from 4·85 to 15·89 per cent. of the metals was dissolved.

Since it requires 130 parts of potassium cyanide and 106·5 of chlorine to dissolve gold and keep it in solution, then a ·2 per cent. solution of chlorine should be almost equivalent to ·25 per cent. of potassium cyanide; these proportions closely approach the strength of solutions used in practice, *e.g.*, in modifications of Munktell process, such as used at Maldon and Cassilis, the amount of chlorine used being from 2 to 4 ozs. to the cubic foot of water, while the ordinary practice in cyanide operations is to use ·1 to ·4 per cent. solutions.

On testing certain roasted ores by both processes, it was found that by using a ·25 per cent. solution of cyanide of potassium and a ·2 per cent. solution of chlorine, that almost an equal quantity of gold was dissolved in 72 hours, the slight difference being in favour of the chlorine. With badly roasted ores, such as have been roasted at a low temperature, also those containing large quantities of arseniates, it is not possible to dissolve a high proportion of the gold present either with excess of a saturated solution of chlorine or with potassium cyanide solutions, but with ores which have been properly roasted, and in which the gold is fine, it will be found that an ordinary solution of cyanide will act as well as chlorine, and with the additional advantage that the silver alloyed with the gold will be dissolved and may be recovered also.

Table showing the Solubility of Gold-Silver Alloys.

Solvent—·25 per cent. Potassium Cyanide Solution—Circulating.

Number of hours in solution				65	123	197	367	597	Composition of Alloy after 597 hours.	
Composition of Alloy.			Weight taken in Grains.	Weight after 65 hrs.	Weight after 123 hrs.	Weight after 197 hrs.	Weight after 367 hrs.	Weight after 597 hrs.		
No.	Gold.	Silver.							Gold.	Silver.
1	100	trace	1·760	1·682	1·600	1·505	1·144	·808	100	—
2	95	5	2·094	2·018	1·872	1·640	·940	·610	90·9	9·1
3	90	10	1·770	1·705	1·584	1·490	1·297	1·150	86·2	13·8
4	80	20	1·820	1·740	1·624	1·470	1·087	·995	75·4	24·6
5	70	30	2·050	1·840	1·762	1·612	1·104	·774	69·8	30·2
6	60	40	2·146	2·030	1·832	1·686	1·150	·794	60	40

LOSS OF WEIGHT EXPRESSED IN PERCENTAGE.

1	100	trace	100	4·43	9·09	14·49	35·00	54·1
2	95	5	100	3·63	10·60	21·68	50·14	70·9
3	90	10	100	3·67	10·51	15·82	26·73	35·0
4	80	20	100	4·39	10·77	19·23	40·27	47·5
5	70	30	100	10·20	14·05	21·36	46·01	62·2
6	60	40	100	5·45	14·63	21·71	46·41	63

SOLVENT—·25 PER CENT. POTASSIUM CYANIDE SOLUTION—STATIONARY.

Number of hours in solution				48	84	48	84
No.	GOLD.	SILVER.	Weight taken.			Percentage dissolved.	
1	100		2·080	2·044	1·985	1·73	4·57
2	95	5	2·006	1·926	1·836	3·99	8·47
3	90	10	2·034	1·966	1·889	3·34	7·12
4	80	20	2·049	1·992	1·936	2·78	5·51
5	70	30	2·016	1·936	1·879	3·91	6·78
6	60	40	2·047	1·963	1·822	3·61	10·99

It would thus appear that the most effective cyanide solution (proved by Maclaurin to be a ·25 %) is not so rapid in action as the chlorine solution usually worked with in practice, but it must be borne in mind that the chlorine solution (·4 %) is twice as strong as the cyanide solutions generally used. I should also have mentioned that during the progress of the experiments it was noticed that wherever the strips touched the containing vessels they were not attacked so much at those points. This will account for small irregularites observed.

TABLE SHOWING THE SOLUBILITY OF GOLD-SILVER ALLOYS.

SOLVENT—SATURATED SOLUTION OF CHLORINE WATER.

No.	Composition. GOLD.	SILVER.	Weight taken.	Weight after 90 hrs.	Loss.	Per. cent. dissolved.
1	100	trace	2·014	·994	1·020	50·64
2	95	5	2·014	·300	1·714	85·10
3	90	10	2·040	·630	1·410	69·11
4	80	20	2·023	·438	1·585	78·34
5	70	30	2·036	·620	1·416	69·05
6	60	40	2·038	·882	1·156	59·66

Each strip of gold was immersed in 50 cc. of water, through which a continuous stream of chlorine was allowed to pass.

SOLVENT—DILUTE SOLUTION—CHLORINE WATER.

No.	Composition. GOLD.	SILVER.	Weight taken.	Weight after 184 hrs.	Weight after 304 hrs.	Per cent. loss of weight 184 hrs.	Per cent. loss of weight after 304 hrs.
1	100	trace	1·856	1·811	1·766	2·42	4·85
2	95	5	2·000	1·874	1·840	6·30	8·00
3	90	10	2·060	1·885	1·831	8·05	11·11
4	80	20	1·822	1·760	1·721	3·40	5·54
5	70	30	1·560	1·527	1·468	1·47	5·90
6	60	40	1·560	1·437	1·312	7·94	15·89

Solution was made so that it contained ·1 % of chlorine. Non-circulating.

The experiment with a 95 % alloy, 95 Au., and 5 Ag., was as follows:—

2·011 grains of gold – ·4 % chlorine solution.

Weight after 96 hrs. in circulating solution } 1·554 grains.

Loss of weight: 96 hrs. = ·457 grains.

And % loss of weight is 22·7.

ART. X.—*Two new Victorian Palæozoic Sponges.*

BY T. S. HALL, M.A.

(Demonstrator and Assistant-Lecturer in Biology in the University of Melbourne).

[Read 8th September, 1898.]

(With Plate XIV.).

Protospongia oblonga, n.sp. (Pl. XIV., Figs. 1–3.

Sponge vasiform; width about 4 cm.; height of the imperfect specimen about 5 cm., tapering roundly towards the base. Spicular meshwork with oblong interspaces. Spaces between the primary spicules about 3 mm. broad and 4 mm. long. Primary and secondary spicules present, but apparently none of a higher order. Flesh spicules closely covering the interspaces, their true shape and arrangement being uncertain, some appearing merely as short straight rods and others as small crosses.

The skeleton is pyritized and preserved in a hard black shale, which adheres in a thin film to the surface of the spicules so that they show as fine raised lines, or where removed, as distinct grooves. The ends of the primary spicules are seen to overlap in a few instances, and occasionally separation has taken place along the oblique line of junction, thus showing the essential Lyssakine nature of the sponge. The pyritous replacement of the spicules has occasionally been dissolved, either wholly or partly, leaving a hollow cast, and one such cast shows a canal running down perpendicularly to the plane on which the sponge lies, thus clearly demonstrating the presence of a fifth ray. Dr. G. J. Hinde[1] points out the natural difficulty which exists in detecting a fifth ray if it were present, and speaking of the Quebec Hexactinellidæ generally, says that judging by the analogy of allied recent forms it is probable that, in most cases, these spicules were furnished with a fifth ray at right angles to the other four. Both before and after this date, however, he

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1 Proc. and Trans. Roy. Soc., Canada, vol. vii., 1890, sec. iv., p. 36.

speaks of Protospongia as having cruciform spicules.[1] Rauff[2] says that in the family of Protospongidæ the thin wall consists of a single layer of Stauractinen, by which he means the same thing, while further on in the same work he says[3] that rudiments of a fifth arm are frequently displayed, and that the question is an open one as to whether pentactins were not universally present, the radial arm being broken off. In the present case the radial arm can be traced inwards at any rate for more than twice the diameter of the other rays, so that the term rudimentary would hardly apply in the case of this single spicule. Whether all the spicules were of this nature is a point on which the specimen as a whole throws no light.

Skeleton spicules of the first and second order are present, and the spaces which they enclose are oblong in form, their length being about one-and-a-half times their width. The smaller interspaces are crowded with a confused network of flesh spicules, many of which are cruciform, while of others the form cannot be clearly made out.

The species may be readily distinguished from all others of which I can find a record by the oblong character of the meshwork. In addition it differs from *P. reticulata*, mihi, from Bendigo by its general shape.

Locality.—Lancefield. Probably Lower Ordovician. Found by Mr. G. B. Pritchard, to whom I am indebted for the opportunity of examining the specimen.

Stephanella (?) maccoyi, n. sp. (Pl. XIV., Figs. 4, 5).

Form of the sponge an elongate oval. Spicules in the form of oxea, generally straight but occasionally curved, thicker in the middle and gently tapering to a point at each end. Arranged in a radiating manner. Anchoring spicules doubtfully preserved, and if present showing that the longer axis was the vertical one. Flesh spicules not observed. Height about 60 mm. Breadth about 30 mm.

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1 Brit. Mus. Cat. Fossil Sponges, 1883, p. 129. Palæontographical Soc., 1888, vol. xli., p. 105.

2 Palæontographica, vol. xl., 1893, p. 187.

3 *Ibid*, p. 235.

The specimen is preserved as a series of ferruginous grooves in a pale grey decomposed slate, together with limonite pseudomorphs after pyrite in small cubes which are scattered in patches throughout the mass. Owing to the method of preservation it is not certain whether the slightly thicker spicules, which I regard as anchoring ones, do not owe their size and form to the spreading of the iron oxide along the cleavage planes, though I am inclined to the opinion that they were originally larger and stouter than those occurring elsewhere on the slab. If so, then they may be considered as anchoring spicules, in which case the vertical axis is at right angles to that in *Stephanella hindii*, Dawson,[1] from the Utica slate at Ottawa. In this species, Sir J. W. Dawson figures some small cruciform spicules on the outer surface, which he considers to be flesh spicules of this species. I have not been able to detect any such forms in the present specimen as no fine details are preserved, the oxidation of the pyrites having destroyed all traces of the more delicate parts of the skeleton.

Sir Frederick M'Coy, to whom I have shown the specimen, has directed my attention to the spicule shown in Fig. 5, and is of opinion that possibly it indicates the presence of V or Y shaped spicules, though of course, owing to weathering, it is impossible to speak with certainity on the point. There are other places where similar appearances are exhibited, but I think that oxea which evidently cross one another can be found lying approximately parallel to each of the arms of the V, and this being so I am inclined to regard the apparent forking as due merely to the accidental juxtaposition of two oxea. Should forked spicules of this nature occur the sponge cannot of course be monactinellid, but would probably be referable to the Tetractinellidæ. After careful consideration I am inclined to the opinion that the sponge finds its true position amongst the Monactinellidæ, and I refer it doubtfully to *Stephanella*, Hinde.[2] From *S. hindii* it differs in shape, for in Sir J. W. Dawson's species the greatest length is horizontal while in the present one it is vertical. The determination of the base of the specimen depends in part on the recognition of the

[1] Trans. Roy. Soc. Canada, 2. S., vol. ii., 1896, sec. 4, p. 116.

[2] Geol. Mag., 1891, p. 22.

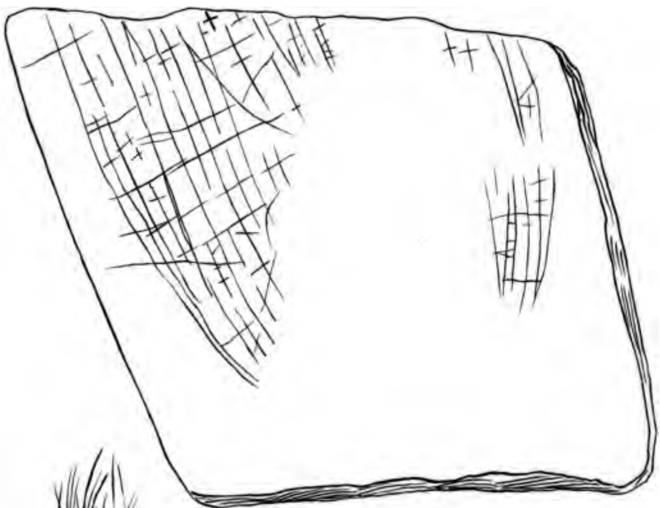

Fig 1.

Fig. 4.

Fig. 2.

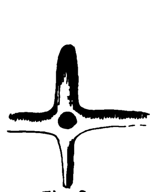

Fig. 3.

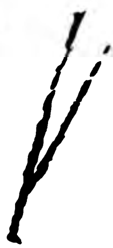

Fig. 5.

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anchoring spicules, a point on which, as mentioned above, certainty cannot be expressed, and in part on the arrangement of the ordinary spicules, which as Fig. 4 shows appear to radiate from a point about one-third of the height of the sponge above what is here regarded as the base. It is a much larger form than *S. sancta*, Hinde.[1]

I have dedicated the species to Sir F. M'Coy, who has kindly allowed me access to Rauff's great work, and has discussed several points in connection with the specimen with me.

Locality.—Found by Mr. G. Alec. Thomson, of the Bendigo School of Mines, about 200 yards east of the Diamond Hill State School, Bendigo, associated with *Tetragraptus fruticosus* and other typical Bendigo graptolites of Lower Ordovician age.

EXPLANATION OF PLATE XIV.

Fig. 1.—*Protospongia oblonga*, n. sp., from Lancefield, slightly enlarged.

Fig. 2.—*Protospongia oblonga*, n. sp., from Lancefield, portion enlarged to show flesh spicules.

Fig. 3.—*Protospongia oblonga*, n. sp., from Lancefield, hollow imprint of a spicule enlarged, to show occurrence of a fifth ray, the presence of which is indicated by a cylindrical hole passing down at right angles to the surface.

Fig. 4.—*Stephanella maccoyi*, n. sp., from Diamond Hill, Bendigo, slightly enlarged.

Fig. 5.—*Stephanella maccoyi*, n. sp., from Diamond Hill, Bendigo, doubtful indication of the presence of forked spicules.

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1 *Ibid.*

Art. XI.—*Description of two new Species of Australian Land Leeches, with Notes on their Anatomy.*

By ADA M. LAMBERT, M.Sc.

(Plates XV., XVI.).

(Communicated by Professor Baldwin Spencer).

[Read 13th October, 1898.]

In a previous paper communicated to this Society, I described the anatomy of *Philæmon pungens*, a land leech found, so far as is yet known, in Victoria, New South Wales and Tasmania.[1]

In his memoir on the leeches of Japan, Professor Whitman refers to an Australian land leech sent to him by Professor Haswell, and says:—

"The Australian species, for which I am indebted to Mr. Haswell, differs from all other species that I have thus far examined in having only two jaws. The latero-ventral jaws are present, but the median dorsal jaw is entirely absent. This remarkable distinction, taken together with the fact that the genital orifices are separated by seven and a half rings instead of five, as in the case of most other land leeches, seems to make necessary the establishment of a new genus, for which I propose the name Geobdella."

There has been apparently no description published of this species referred to by Whitman. *Philæmon pungens* differs from the above in that it has four annuli to a segment and the reproductive orifices are separated by four rings. Through the kindness of Mr. T. Steel and Mr. C. French, I have recently had the opportunity of examining two other forms of land leeches; the first of these which came into my hands agreed with *Philæmon pungens* in the presence of two jaws, but differed from it in possessing five annuli to the segment, and in having seven annuli between the pores.

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[1] Proc. Roy. Soc. Vic., N.S., vol. x., 1898, p. 211.

The second, apart from external colour markings, differed only from the latter in having seven and a half annuli between the openings. These two are evidently more closely allied to one another than either is to Philæmon, and the three are sharply marked off from other leeches by the presence of two jaws.

There can be little doubt that the one with seven-and-a-half annuli between the pores is identical with the one referred to the genus Geobdella by Whitman, and for this I propose the name of *G. whitmani* [Fig. 2.]

The form with seven annuli between the pores is evidently closely allied to, though distinct from this, and for it I propose the name of *G. australiensis* [Fig. 1.]

The descriptions of these are as follows :—

Geobdella whitmani, n. sp.

Total length in alcohol upwards of 40 mm. The number of annuli, including those represented at the anterior end by the four oculiferous rings, is 95. The first complete annulus is the 5th, and the last complete the 92nd.

Eyes, five pairs, first four in front of the first distinct annulus, the fifth on the 7th annulus, and separated from the fourth by two annuli.

Nephridial pores open on the last annulus of the segment, the first are in front of the fifth eye, and the last underneath a prominent papilla as in Philæmon, in this case formed by the 93rd and 94th annuli.

The male reproductive opening is between the 29th and 30th, and the female in 37th annulus.

Colour markings. Body warm rusty brown, dorsally there is a more or less distinct light band edged by a dark line, and on either side are patches of darker pigment. In each of these is a light band and occasionally these lighter bands may be continuous with one another, forming on either side a lateral band which may run along the greater part of the length of the body. The dorsal band does not usually extend along the posterior sixth of the body, which is here mottled with dark patches.

Segs. I.–III. have no clearly marked annuli, and bear the first three pairs of eyes.

Seg. IV. consists of 3 annuli, the most anterior bearing the fourth pair of eyes.

Seg. V. also consists of 3 annuli, on the first of which is developed the fifth pair of eyes.

Seg. VI. is represented by 3 annuli, 10, 11, 12, the first bearing segmental organs.

Seg. VII. and succeeding segments to XXII. consist of 5 annuli, the first always bearing well-marked segmental organs.

Segs. XXIII.–XXXIII. are represented by the 93rd, 94th, 95th annuli and the acetabulum.

Habitat. Woombye, Queensland (C. French, Esq.); New South Wales (Professor Haswell).

Geobdella australiensis, n. sp.

Total length in alcohol upwards of 48 mm. The total number of rings is 95, this includes those indistinctly marked at the anterior end but represented by eyes [Fig. 1.]

The first complete annulus is the fifth, and helps to form the ventral lip of the anterior sucker; the last complete annulus is the 92nd.

Five pairs of eyes—the first three pairs undoubtedly represent the first three segments, consisting of only one annulus each, but these are not distinguishable. The fourth pair is borne on the 4th annulus, which is marked off from the 5th but not from the 3rd. The fifth pair is separated from the fourth by two annuli and is carried in the 7th annulus.

Nephridial pores open on the last annulus of the segment and can be easily detected along the white lateral line in every 5th annulus. The first are in front of the fifth eye, and the last under a papilla close to the acetabulum and formed by the 93rd and 94th annuli.

The male reproductive opening lies between the 29th and 30th annuli, and female between 36th and 37th.

Colour markings—alcohol specimens. The anterior portion of the body (about 1–39 annuli), a dull brown, posterior to this bluish-black. Along each side, separating the dorsal from the

ventral surface, is a distinct, white, lateral line, along which the nephridia open, a pair in each segment.

At the posterior end certain white patches occur on the dorsal surface which seem to be constant.

On the 85th and 86th annuli on each side of the mid-dorsal line is a small oval patch of white nearer to the lateral line, and extending into the 84th is a similar area, and continuing this posteriorly from the 89th to the 92nd is a white line. On either side of the median line is a diamond-shaped area extending from the 90th into the 89th and 91st annuli. A triangular patch occurs at the extreme posterior end, the apex being in the mid-dorsal line of the 93rd annulus and the base along the 95th.

Segs. I.–III. are indistinguishable, but are represented by the first three pairs of eyes which, however, are not borne on separate annuli.

Seg. IV. represented by 4th, 5th and 6th annuli, bears the fourth pair of eyes on an annulus not separated from segment III.

Seg. V. consists of 7th, 8th and 9th annulus, the fifth pair of eyes being on the 7th annulus.

Seg. VI. consists of 10th, 11th and 12th annuli, the most anterior of these bearing the segmental sense organs.

Segs. VII.–XXII. consist of five annuli each; the first annulus always carries the segmental sense organs, and on the last opens the nephridiopore.

Segs. XXIII.–XXXIII. are represented by the last three rings, 93, 94, 95, and the acetabulum as seen by the ganglia.

There are in this form ten segmental sense organs on the most anterior annulus of each segment, six on the dorsal side of the lateral line, and four on the ventral. Of the three dorsal pairs the middle one corresponds to the eye and the outer pair is placed close to the lateral line. Of the two ventral pairs the outer pair is nearer to the mid-line than in the case of the dorsal.

Habitat. Moss Vale, New South Wales (T. Steel, Esq.).

Anatomical Notes.

With regard to the anatomy of these new forms, in the main they resemble *Philæmon pungens.* There are, however, certain points to which attention may be called.

I. *Alimentary Canal.*—In segment XVIII. as in Philæmon the eleventh pair of diverticula are given off and extend backwards through segments XIX., XX., XXI., and XXII. The main part of the alimentary canal passes through the segments XIX. and XX. as a straight tube, but in segment XXI. from its ventral surface arises a very definite duct-like portion leading into the intestine. Where the main part is connected with the narrow duct a very definite cæcum is developed in both these forms but more especially in *G. australiensis.* The intestine passes back through the remaining segments and opens on the dorsal surface between the 95th annulus and the acetabulum. At the anterior end of the intestine in segment XXI. it is continued forward as a blind pouch in *G. australiensis* as far as the 78th annulus and in *G. whitmani* to the 83rd.

II. *Posterior Organs.*—In connection with the 11th diverticula are a pair of posterior organs in structure resembling closely those found in Philæmon.

The position, however, differs. Instead of lying in segment XIX. and in the mid-ventral line they lie in both *G. whitmani* and *G. australiensis* in segment XXI. and occupy a more lateral position.

The ducts from these organs pass back into the inner and almost extreme posterior surface of the diverticula, and on account of the organs being two segments further back, the ducts are shorter. They are also much wider and can easily be detected in a dissected specimen. The glands do not appear to possess any pigment in the longitudinal grooves.

III. *Salivary Glands.*—Connected with the jaws. These are exceptionally well developed in both these species, much more than in *Philæmon pungens.* They are arranged in five distinct groups [Fig. 5], some opening on the jaws between the denticles as in Philæmon, others opening directly into the buccal cavity. Of these there are three distinct masses connected with each jaw:

1. A dorsal mass which is the largest and made up of several lobules. This extends as far back as the anterior margin of segment X. [Fig. 5, 1.]
2. The ventral mass which lies about the same level is also lobulated [Fig. 5, 3.]

3. The lateral mass, which is much smaller than either dorsal or ventral glands, lies on the dorsal side in front of the buccal cavity, the ducts of which pass back and enter the jaw beneath the longitudinal muscles [Fig. 5, 4.]

In addition to these there is a large lobulated mass which is situated on the dorsal surface under (1). The ducts from this extend forward and open on the dorsal surface of the buccal cavity near to the angle of the jaw [Fig. 5, 2.] The remaining group is made up of much smaller glands, the cells of which are not arranged together in masses, nor do their ducts run together in groups. They open into the buccal cavity on all sides [Fig. 5, 5.]

All the salivary glands are made up of single more or less spherical cells, of granulated protoplasm. The nucleus is situated in the distal end of the cell and from the opposite end arises the duct, which is continued to open on the surface [Fig. 8.]

It is remarkable that each unicellular gland is connected with the exterior by its own duct, so that in many instances the ducts extend through several segments. By the contraction of the muscles of the jaws, the secretion is forced out between the denticles as soon as the bite is made.

The salivary glands are all well supplied with blood from the lateral blood vessel.

IV. *Œsophageal Glands.*—In the paper on *Philæmon pungens*[1] I have referred to racemose glands in the œsophagus, which I called the salivary glands; these I now prefer to call the œsophageal and to keep the name "salivary" for the unicellular glands just described.

The same description applies to the œsophageal glands of these species as to the glands of Philæmon, namely racemose, consisting of large clear cells, and opening almost directly on to the surface of the œsophagus [Fig. 9.]

V. Connected with the cirrus sac is a strong glandular development consisting of small unicellular glands, some of which open directly into the cirrus sac, and others on to the surface of the skin.

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1 *L.c. supra.*

These are in all probability modified epidermic cells like those of the head. Each opens by its own duct. The glandular cells in this position are smaller than those of the salivary glands, and take the stains, such as Mayer's hæmalum, like the glands in the head, while the salivary glands take indigo rather than hæmalum.

DESCRIPTION OF PLATES XV., XVI.

Fig. 1.—Diagram *Geobdella australiensis*, showing the number of segments, annuli, nerve ganglia, nephridiopores, and reproductive openings.

Fig. 2.—Diagram of *Geobdella whitmani*, showing the relation of the reproductive openings to the annuli.

Fig. 3.—Diagram of *G. australiensis*, showing the relation of the posterior organs to the alimentary canal, and the intestine with its cæcum.

Fig. 4.—Diagram of *G. whitmani*, showing diverticula, intestine and posterior organs.

Fig. 5.—Diagrammatic representation of the salivary glands, showing their relation to the jaws and the buccal cavity on the right side of the nerve cord. 1. Large dorsal mass opening on surface of the jaw. 2. Dorsal mass opening into the buccal cavity. 3. Ventral mass opening on the surface of the jaw. 4. Small dorsal anterior mass opening on the surface of the jaw.

Fig. 6.—Transverse section through *G. whitmani* (camera lucida), showing the position of the salivary glands. Gl. 1. Dorsal gland opening on the jaw. Gl. 2. Dorsal gland opening into buccal cavity. 3. Ducts of the ventral salivary glands opening on the jaws. B.v. Lateral blood vessel. Neph. Nephridium 1.

Fig. 7.—Transverse section across *G. whitmani* (camera lucida) at the level of the pharynx passing into the œsophagus. Ph. pharynx wall. Œs. gl. œsophageal gland. Gl. 1. dorsal salivary gland opening on the jaw. D. 1. ducts of dorsal salivary gland connected with the jaws. D. 2. ducts of salivary gland (Gl. 2) to open

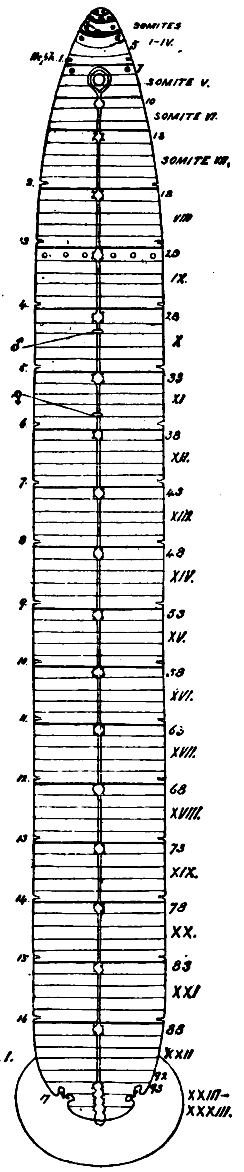


FIG. 1.

CEOBDELLA AUSTRALIENSIS.

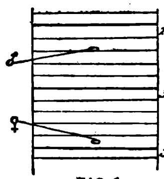
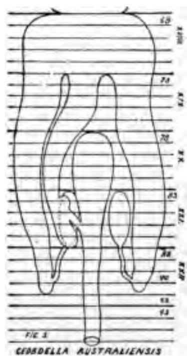
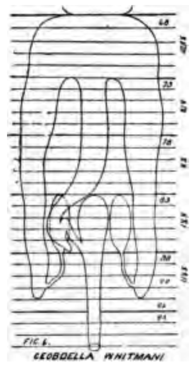
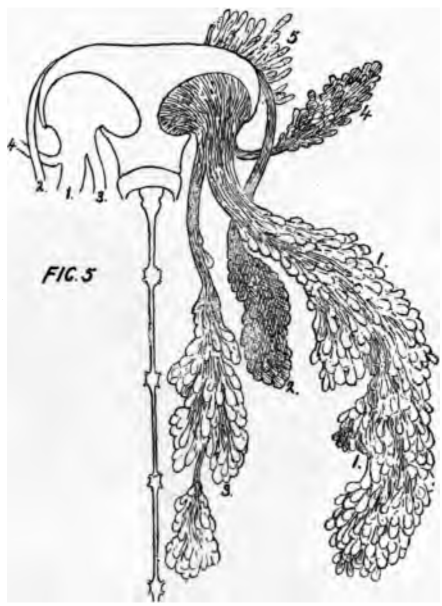


FIG. 2.
C. WHITMANI.







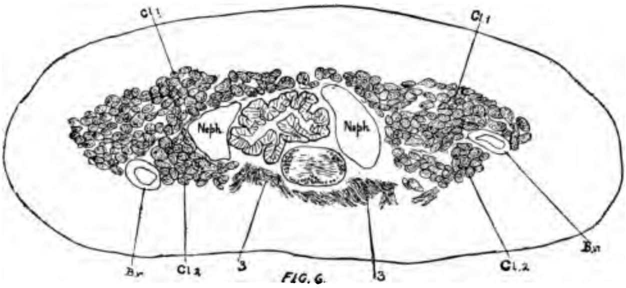


FIG. 6.

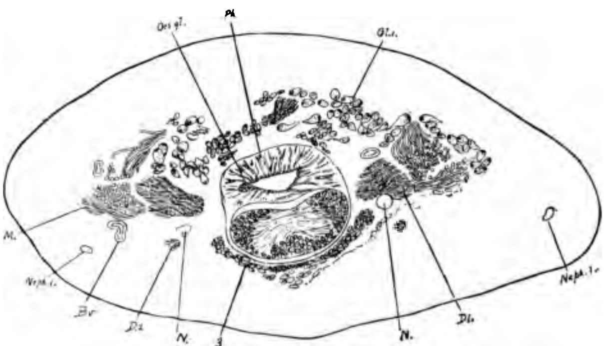
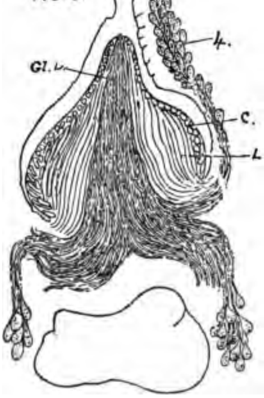


FIG. 7.

FIG. 8.



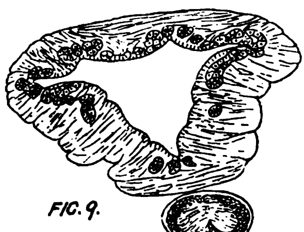


FIG. 9.

into the buccal cavity. 3. ventral salivary glands connected with jaws. B.v. lateral blood vessel. Neph. excretory duct leading to nephridiopore of the first pair of nephridia. M. longitudinal muscles of the jaws continued into the body wall. N. nerve arising from a ventral ganglion.

Fig. 8.—Longitudinal vertical section through the jaw showing Gl. d. mass of gland ducts made up those from Gl. 1, Gl. 3, Gl. 4. 4. salivary gland on the dorsal surface anterior to the buccal cavity. L. longitudinal muscles of the jaws. C. circular muscles of the jaws.

Fig. 9.—Transverse section through the œsophagus to show the œsophageal glands.

ART. XII.—*Victorian Graptolites: Part II. The Graptolites of the Lancefield Beds.*

BY T. S. HALL, M.A.,

Demonstrator and Assistant Lecturer in Biology in the University of Melbourne.

(With Plates XVII., XVIII., XIX.).

[Read 10th November, 1898].

The occurrence of graptolites at Lancefield was first recorded by myself some years ago when I described a species of Dictyonema from the locality.[1] Mr. G. B. Pritchard then followed with two papers on the graptolite fauna which will be subsequently referred to. The stratigraphical position was briefly dealt with by myself in a paper on the geology of Castlemaine, in which I showed that the Lancefield beds underlie the Bendigo series, or, as I there called it, the Tetragraptus fruticosus zone.[2] A further examination of the graptolites from the locality has strongly confirmed the views I then held, as an examination of the present paper will show.

The beds are very rich in individuals in a good state of preservation, and besides my own collection I have had the advantage of examining those of Messrs. G. Sweet, F.G.S., and G. B. Pritchard, and must acknowledge my thanks to them for placing their large series so unreservedly at my disposal.

The graptolites are preserved in an almost black, highly pyritous shale intercalated with fine grained intensely hard siliceous beds.

The only other fossils I have seen in the beds are sponge remains, a new species, Protospongia oblonga, being described in the present volume, and what appears to be a Lingulocaris allied to, if not identical with L. maccoyi Eth. jr.

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1 Proc. Roy. Soc. Vic., N.S. iv., 1892, p. 7.

2 *Ib.*, viii., 1894, p. 74.

All the specimens come from a small quarry a few hundred yards to the north of the now deserted Mount William railway station. There are at least three distinct bands containing fossils, but if any palaeontological differences exist between them they are very slight, and a collation of the species associated on a large number of slabs has yielded no definite results. This point must be insisted on, as otherwise, the association of the forms here dealt with, would, by European analogy, induce the opinion that several very distinct horizons were confused, which is certainly not the case.

Bryograptus, Lapworth, 1880.

Bryograptus victoriae, n.sp.

(Pl. XVII., Figs. 1, 2).

Branches diverging at first at about 50°, curving towards one another and again dividing at about 70° or 80°, forming a bell-shaped hydrosome. Sicula with a prolonged virgula of about 2 mm. in length. Thecae straight-sided, apertural margin at right angles to the branch, outer margin at an angle of about 10° or 12°; about 10 in 10 mm. Breadth of branches about 0·5 mm.

There is no evidence of overlapping of the thecae in any of the specimens I have seen.

The fine thread extending from the pointed end of the sicula is morphologically a virgula, and no useful purpose is served by applying a different name to it. Its presence has of course long been recognised in such forms as Didymograptus caduceus, though its true nature was long misunderstood.

Bryograptus clarki, n.sp.

(Pl. XVII., Figs. 3, 4).

Branches straight and inclined at an angle of about 135°, 0·5 mm. broad, giving off branches on their inner side near the sicula. These four branches again branch at a little more than 3 mm. from their point of origin. Sicula with a short virgula. Thecae about 10 in 10 mm., straight sided; apertural margin inclined at about 100° to the axis of the branch; outer margin

forming an angle of 20° with the same; free for one half their length and indenting the branch about one half its width.

I have much pleasure in dedicating this species to a former pupil, Mr. George Clark, who was the first to find graptolites in these, the oldest Australian graptolite beds yet discovered.

Leptograptus, Lapworth, 1873.

Leptograptus antiquus, n. sp.

(Pl. XVII., Figs. 5, 6).

Polypary of extreme tenuity. The two branches diverging at about 180° from the sicula, and slightly curving with the thecae on the concave side; these primary branches at times give off a secondary branch. Breadth of branches 0·1 mm. Thecæ 7 in 10 mm., not in contact with one another; apertural margin straight or, when compressed in a different manner, slightly concave; inclined to the axis at an angle of 90°; outer margin slightly concave and inclined at an angle of 30°. Breadth from tip of theca to back of branch about 0·4 mm.

Specimens giving off a secondary branch are not very common, forms with only two branches being of far more usual occurrence. The branching usually takes place in the neighbourhood of the sicula and I have seen a few with four branches produced in this way. In the example figured the branch is given off at a considerable distance from the sicula, it is well preserved and there is no doubt as to the branching really taking place as figured.

Owing to the great delicacy of the polypary specimens frequently occur in a somewhat tangled state, and in such examples the sicula and first and second thecae are often more clearly preserved than the rest of the specimen. The species is fairly common and is easily distinguished from Didymograptus pritchardi n. sp. with which it is associated and with which it is perhaps liable to be confused, by its more slender habit and by the much more distant thecae which do not overlap.

The genus has already been recorded from Lancefield by Mr. G. B. Pritchard.[1]

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[1] Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

Didymograptus, McCoy, 1851.

Didymograptus pritchardi, n. sp.

(Pl. XVII., Figs. 7, 9; Pl. XIX., Figs. 8, 10).

Hydrosome very slender, the two branches at first forming an angle of about 140° with one another, then gently and evenly curving, with the concavity on the theca bearing side. Not infrequently a third branch is given off, from the neighbourhood of the second theca, while rarely another branch arises from a similar position on the other side of the sicula. Branches about 0·5 mm. wide, and may reach a length of over 12 cm. Thecae about 10 in 10 mm., very long and narrow, overlapping apparently about one half their length; apertural margin straight or slightly convex, at right angles to the branch. Outer margin at first making a very small angle with the branch, but towards the aperture becoming deeply concave and forming an acute point. Virgula at times extending for a considerable distance from the proximal end of the sicula.

This slender form is fairly common and almost always has but two branches developed, so that I have ventured to refer it to Didymograptus. Had the four branched forms been at all common, instead of rare, they might have been regarded as the normal ones, and those with two or three branches as having arisen by the suppression of one or more branches. The exceedingly narrow proximal part of the thecae led me at first to think that no overlap took place, and that the form was a Leptograptid, but that the thecae do overlap is clear from the examination of a specimen preserved partly in relief. The virgula is at times visible as an exceedingly fine thread and may reach the length of 4 mm.

Didymograptus taylori, n. sp.

(Pl. XVII., Figs. 11, 12).

Branches diverging at an angle of from 140° to 160°, straight, 0·5 mm. broad near their origin and gradually increasing to 0·75 mm. at their distal end, each from about 5 to 10 mm. long. Sicula about 1·5 mm. long. Virgula extending for some 3 or 4

mm. and scarcely visible except under the lens. Thecae 11 or 12 in 10 mm. slightly expanding towards the aperture, overlapping for one half their length, two and a half times as long as broad; apertural margin slightly concave, inclined at an angle of about 80° to the axis, so that the aperture looks slightly inwards; outer margin gently concave and inclined at an angle of 25°.

In one case the virgula, at a distance of 4 mm. from the sicula, appears to terminate in a pear-shaped vesicle about 0.7 mm. in length, being attached to its smaller end. As, however, the virgula is not exposed the whole way, the connection is not certain and my attempts to clear it have not been successful.

Named as a tribute to the memory of the late Norman Taylor of the Victorian Geological Survey.

Tetragraptus, Salter, 1863.

TETRAGRAPTUS DECIPIENS, n. sp.

(Pl. XVII., Figs. 13–15; Pl. XVIII., Figs. 16–19).

Tetragraptus quadribrachiatus, Pritchard (*non* J. Hall). Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

Form stout, branches arising close to the sicula, apparently from the second and third thecae, and from 0·5 to 1 mm. broad. Thecae slightly expanding, overlapping for about one half their length; apertural margin concave, set at an angle of from 95° to 100° to the axis of the branch; outer margin with a slight concave curvative which gently increases near the aperture; inclined at first at an angle of about 10° to the branch and near the aperture of about 30°. Virgula shown as a fine line, often about 7 mm. in length.

Figures are given showing the apparent variation produced by the polypary being embedded in different positions. Fig. 13, which represents a common method of preservation of young specimens, shows that the angle of divergence of the branches is less than 180°. With increase in size this position becomes less common, and a regular cross is displayed. In this latter case the thecae and sicula are naturally not well shown and the likeness to similarly preserved specimens of T. quadribrachiatus

is pronounced. Numerous examples occur connecting these two extremes, and there can be but little doubt of their identity, though at first sight they seem sufficiently distinct. The presence of the prolonged virgula, the much narrower thecae, and their smaller angle of inclination to the axis of the branch sufficiently distinguish this species from T. quadribrachiatus.

Clonograptus, Nicholson, 1873.

Clonograptus flexilis, J. Hall.

(Pl. XIX., Fig. 20).

Graptolithus flexilis, J. Hall. Geol. Surv. Canada. Rep. for 1857, p. 119. *Id.* Grap. Quebec Group, 1865, p. 103, pl. x., f. 3-9. Wdct. 8, p. ii.

Hydrosome bilaterally symmetrical, copiously branching. Branches of the first order in the same straight line; those of the second order diverging at an angle of about 100°; those of the third order vary so much that measurements are of no value, a range of from 50° to 100° having been observed. Branches of a still higher order seem to diverge at a fairly constant angle of between 30° and 40°, slightly curving towards one another after the bifurcation. The width of the primary branches is a little more than 1 mm., and from this they gradually decrease in breadth till they become scarcely perceptible to the unaided eye. Fairly rigid at first, they become more flexible distally. Branches of the first order about 1 mm. long; of tho second 4 mm.; of the third about 5 mm.; of the fourth about 8 mm.; the distance between bifurcations of a higher order increasing greatly but irregularly. Thecae not observed.

The occurrence of this species at Lancefield has already been recorded by Mr. G. B. Pritchard[1] and the figure is from one of his specimens, it being more distinct than any of my own. All the specimens I have seen, about a dozen altogether, are somewhat stouter in their proximal parts than Hall's description and plate of the Point Lévis specimens indicate, in this particular agreeing more closely with his woodcut[2] which has been reproduced by Nicholson.[3]

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1 Proc. Roy. Soc. Vic., N.S. vii., 1895, p. 30.

2 *L.c.*. p. 11; and Twentieth Report of the State Cabinet of N.Y., p. 176, f. 9.

3 Monogr. British Grap., f. 51, p. 108.

Clonograptus magnificus, Pritchard.

Temnograptus magnificus, Pritchard. Proc. Roy. Soc. Vic., N.S., iv., 1891, p. 58, pl. vi., figs. 1-3; *and* vol. viii., 1894, p. 29.

The gigantic size of the type specimen, about one metre in diameter, is very remarkable. Fragments are not uncommon at Lancefield, and I have seen a specimen, said to be from Bendigo, which I believe to be the same species.

Clonograptus rigidus, J. Hall.

(Pl. XVIII., Fig. 22; Pl. XIX., Fig. 21).

Graptolithus rigidus. Geol. Surv. Canada, Report for 1857, p. 121; *id.* Grap. Quebec Group, 1865, p. 105, pl. xi., figs. 1-5.

Branches numerous, of small diameter and fairly rigid becoming somewhat flexible towards their extremities. Primary branches from 1 to 1·5 mm. long and in a straight line; secondary branches 4, or rarely 5 mm. long, branching at an angle of from 90° to 120°; tertiary branches from 5 to 9 mm. long, forming at an angle of from 60° to 90° with each other. The subsequent branches diverge at an angle of about 30° or 40° and usually are but slightly flexible. In some cases however, probably from maceration, the whole hydrosome is so devoid of rigidity that the branches as far down as the tertiaries are much curved and tangled. The diameter of the branches is at first about 0·5 mm., and evenly and gradually diminishes towards their distal ends. Thecae 11 in 10 mm., slightly expanding; apertural margin perpendicular to the branch; outer margin slightly concave, inclined at about 15°.

Clonograptus rigidus, *var* tenellus, Linnarsson.

(Pl. XVIII., Figs. 23–25).

Dichograptus tenellus, Linnars. Ofv. kon. Vet. Ak. Förh., Årg. 20, 1871, No. 6, p. 794, t. 16, figs. 13-15.

Clonograptus tenellus, Moberg. Sver. Geolog. Undersök. Afhandl. och. Upsatter. C., 125, p. 3, t. 1, f. 1-3, 1892.

Hydrosome slender, branches rigid, about 0·2 to 0·5 mm. broad. Sicula small, a virgula 1 mm. in length occasionally

visible. Primary branches in a straight line each about 1 mm. long. Secondary branches forming an angle of about 90° with each other, about 2 or 3 mm. long. Tertiary branches diverging at about 65°, and 4 or 5 mm. long. Those of the fourth order branching at 50°. Thecae narrow, apertural margin nearly at right angles to the branch; outer margin straight or slightly concave, inclined at an angle of about 10°; 10 or 11 present in 10 mm., and present on secondary and all succeeding branches, but not observed on the primary.

The above description is drawn up from specimens before me and agrees well with the very full one given by Moberg of the Swedish forms. Linnarsson in his original description gives 7-8 thecae as the number in 10 mm., as also does Frech,[1] who had well preserved specimens from the type locality. Moberg however gives 8-10 as the number in the same length, while the Lancefield specimen seem to have 11 pretty constantly.

If the specimens I have identified as C. rigidus and C. tenellus are correctly determined, and to my mind there is no doubt that they are, then there can be no reasonable ground for their specific separation. Were extreme forms alone considered their union under one specific title would be doubtful, but the occurrence of a large number of intermediate examples, which one hesitates to refer to either "species," compels us to unite the whole series under the name of the first described form, C. rigidus. The thecae of both C. rigidus and C. tenellus are similar in shape, about the same number occur in a given space in both forms, while the general appearance of the hydrosome differs only in the smaller build of Linnarsson's species and in its less copious branching. That this is subject to considerable variation the diagrams below will make clear. In drawing them up I have merely measured with dividers and a boxwood scale to the nearest half millimetre. The measurements in each case will be seen to be aggregated round one common mean, and not two, as would be the case if the length of the branches afforded a satisfactory means of separation. Each dot represents a single measurement.

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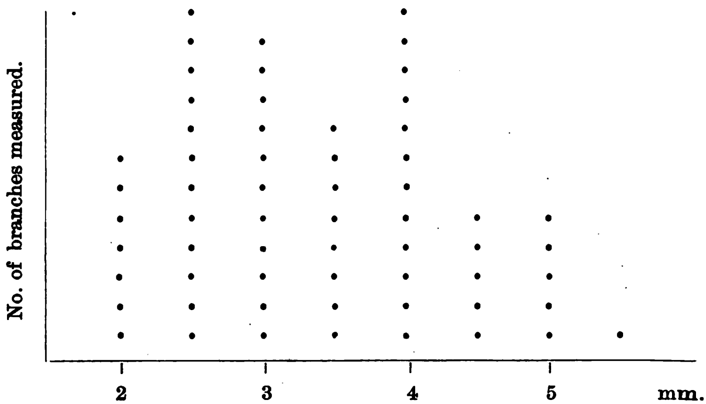
1 Leth. Geog. 1Th. 1B., p. 598, 1897.

DIAGRAM SHOWING LENGTHS OF BRANCHES IN C. RIGIDUS AND C. TENELLUS.

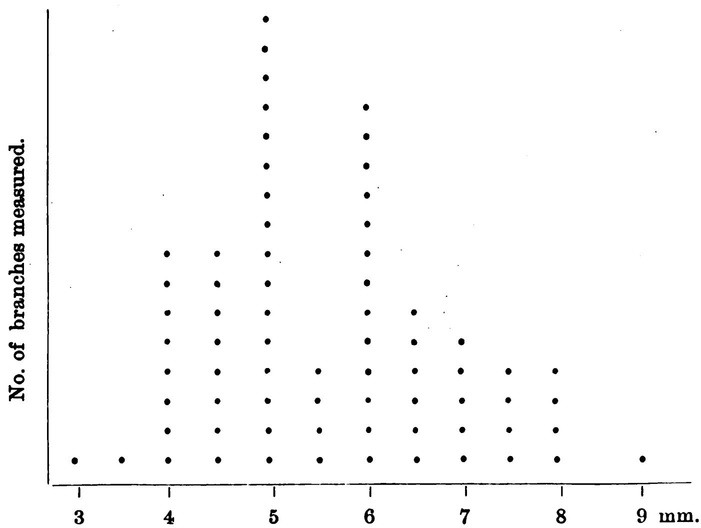
BRANCHES OF SECOND ORDER.

NUMBER OF INDIVIDUAL SPECIMENS 17.



BRANCHES OF THIRD ORDER.

NUMBER OF INDIVIDUAL SPECIMENS 12.



Comparing the measurements of Hall's figures in Grap. Quebec group, with Moberg's description we get the following (in mm.)

	1	2	3
C. rigidus.			
Hall	1 ($\frac{1}{20}$ in.)	3–8	5–10
Moberg	Branches twice the size of those of C. tenellus.		
C. tenellus.			
Moberg	2	4	

One peculiarity which is rather striking is the occurrence of specimens which are so delicate that they are mere phantoms, though associated with others which are well developed. At times a specimen will be fairly broad and distinct at the base and will fade away gradually towards the distal extremity of the branches, so that even with a lens one cannot be certain where the end is. In these examples, as in fact is usually the case, the thecae are embedded and no sicula is visible. Whether this tenuity is real, and due to an under-development of chitin, or whether again it is due to maceration are questions not easy of solution.

One specimen showed primary branches 1·2 mm. long; secondary 5, 5, 4, 4 mm. long; tertiary 6, 8, 7·5, 7·5, 7·5 mm.; diameter of the primary branches 0·5 mm., while the distal ends are so fine as to be scarcely visible. Usually however it is specimens of *var.* tenellus with secondaries from 2-3 mm. and tertiaries from 3-5 mm. long which are thus preserved.

Both varieties are fairly common and frequently preserved on the same slab.

Phyllograptus, J. Hall, 1857.

Phyllograptus ? sp.

(Pl. XVIII., Fig. 26).

I have seen a single specimen which I think is referable to this genus. It is partly covered and not in a good state of preservation, so that nothing but the outline can be made out. The fragment is 25 mm. long and the uncovered part is about 4 or 5 mm. broad. Thecae 10 or 11 in 10 mm., apertural margin

convex, outer margin slightly concave. Attempts made to clear the specimen not being successful I thought it advisable not to endanger it. I have very little doubt that the generic reference is correct, though the occurrence of the form in the Lancefield rocks must be very rare. The specimen was collected by Mr. G. Sweet.

Dictyonema, J. Hall, 1852.

DICTYONEMA MACGILLIVRAYI, T. S. Hall.

(Pl. XVIII., Fig. 27).

Dictyonema grande, T. S. Hall (*non* Nicholson). Proc. Roy. Soc. Vic., N.S. iv., 1892, p. 7, pl. i., ii.; *id.*, Pritchard, *Ib.*, vii., 1895, p. 28.

Dictyonema macgillivrayi, T. S. Hall. *Ib.*, x., 1897, p. 15.

The thecae have been described by Mr. Pritchard and owing to his kindness I am able to give a figure of them from his specimen. Fragments of the species are not uncommon.

DICTYONEMA PULCHELLUM, n. sp.

(Pl. XVIII., Fig. 28–30).

Hydrosome circular, about 15 mm. in diameter; branching dichotomously from the base, at fairly regular intervals. Radial branches about 1 mm. broad. Connecting branches at right angles to these, about 1 mm. apart and about 0·2 mm. broad, expanding at the point of junction with the radial branches. Thecae with slightly concave apertural margin at right angles to the branch; outer margin straight, forming an angle of 25°-30° with the axis of the branch; probably about 7 in 10 mm.

This pretty little form is represented by four examples in the collection of Mr. G. B. Pritchard, and are all on one small slab. One specimen has been compressed laterally, so that the hydrosome was apparently cup shaped, and in this example the thecae are visible near the base. In none of the other examples can I detect any signs of thecae which are most likely embedded at right angles to the bedding plane.

The following is a list of the species obtained :—

Bryograptus victoriae, n. sp.
Bryograptus clarki, n. sp.
Leptograptus antiquus, n. sp.
Didymograptus pritchardi, n. sp.
Didmograptus taylori, n. sp.
Tetragraptus decipiens, n, sp.
Clonograptus flexilis, J. Hall.
Clonograptus magnificus, Pritchard.
Clonograptus rigidus, J. Hall.
,, ,, *var* tenellus, Linnars.
Phyllograptus ? sp.
Dictyonema macgillivrayi, T. S. Hall.
Dictyonema pulchellum, n. sp.

In examining the above list we are confronted by the fact that two of the genera, namely Bryograptus and Leptograptus, are regarded as belonging to entirely different horizons, although here occurring on the same slabs. European geologists consider the former genus as indicative of Cambrian age, while Leptograptus is, according to Lapworth,[1] confined to the Upper Ordovician, although one section of the family Leptograptidae, as represented by Azygograptus, ranges as low as the base of the Arenig. The associated genera at Lancefield forbid us regarding the beds as younger than Lower Arenig, so that we must consider the genus Leptograptus as of greater age in Australia than in Europe. With regard to Bryograptus it is looked on by European geologists, as previously mentioned, as a Cambrian form, and Clonograptus tenellus is referred to the same age. Didymograptus, Tetragraptus, Clonograptus flexilis, C. rigidus, Phyllograptus and Dictyonema of the type herein recorded all occur in the Lower Arenig of Europe and some of the genera range higher.

The stratigraphical position of the American species Clonograptus rigidus and C. flexilis adds another difficulty, since an inspection of the list by Ami in the Report on the Geology of a Portion of the Province of Quebec by R. W. Ells[2] shows that

1 Ann. Mag. Nat. Hist., 5 S, vol. 6, p. 27.
2 Ann. Rep. Geol. Surv. Canada for 1887-8, iii., K, p. 116.

C. flexilis is associated with forms most of which occur in our T. fruticosus zone at Bendigo, while C. rigidus is accompanied by Loganograptus logani which, in Victoria, does not appear till after Phyllograptus typus has become extinct.

There can be no doubt that the Lancefield beds are below the beds which I have elsewhere called the Tetragraptus fruticosus zone[1] where all the genera, except Dictyonema and perhaps Bryograptus occur.

As regards Dictyonema it is not a little remarkable, considering its range both in Europe and America, that not a single specimen has been recognised in Australia from anywhere except Lancefield.

The single specimen which I have doubtfully referred to Phyllograptus is the only one I have seen from the locality and is alone on a small slab.

The question then arises how far below the Bendigo series do the Lancefield beds lies? Are we, on the evidence of the presence of Bryograptus and of Clonograptus tenellus, to regard them as Cambrian, or are we to regard these forms as here ranging into the Ordovician? Owing to the occurrence of Bryograptus and Dictyonema sociale Lapworth has called the Cape Rosier zone of Canada Cambrian,[2] but Ells in the report above quoted, hesitates to follow him till more stratigraphical evidence is available. There is nothing apparently inherently improbable in the Cape Rosier zone being Cambrian, for the so called Quebec group, to which it belongs, and in the district where it occurs, comprises rocks varying in age from Pre-Cambrian to Silurian. With us there is an indication at any rate that the same state of things may possibly occur. Our palaeozoic rocks are remarkable for the persistence of their strike, which is not interrupted by the intervention of even large areas of intrusive granite. Thus the Chewton-Castlemaine Ordovician is interrupted to the north by the belt of Maldon-Elphinstone granite which is about ten miles wide, and yet to the north of the area we again get Ordovician rocks of the same age and the strike is unchanged, being still a few degrees west

1 Proc. Roy. Soc. Vic., N.S. vii., 1894, p. 76.

2 Trans. Roy. Soc. Canada, 1886, p.

of north. At Lancefield the rocks strike N. 15° W. and are cut off to the north by another granite area, that of the Baynton Range, while beyond this again palaeozoic rocks with the same strike occur. Now, if the line of strike of the Lancefield rocks be followed across the granite to Heathcote, a distance of thirty miles, we come to a locality yielding fossils considered by Mr. R. Etheridge, jr., as probably of Middle Cambrian age.[1]

It is true that no great weight can be attached to this fact in the way of supporting the Cambrian age of the Lancefield beds, though it points to the strong probability of the so called metamorphic rocks to the eastward of the graptolite beds at Lancefield being true Cambrian.

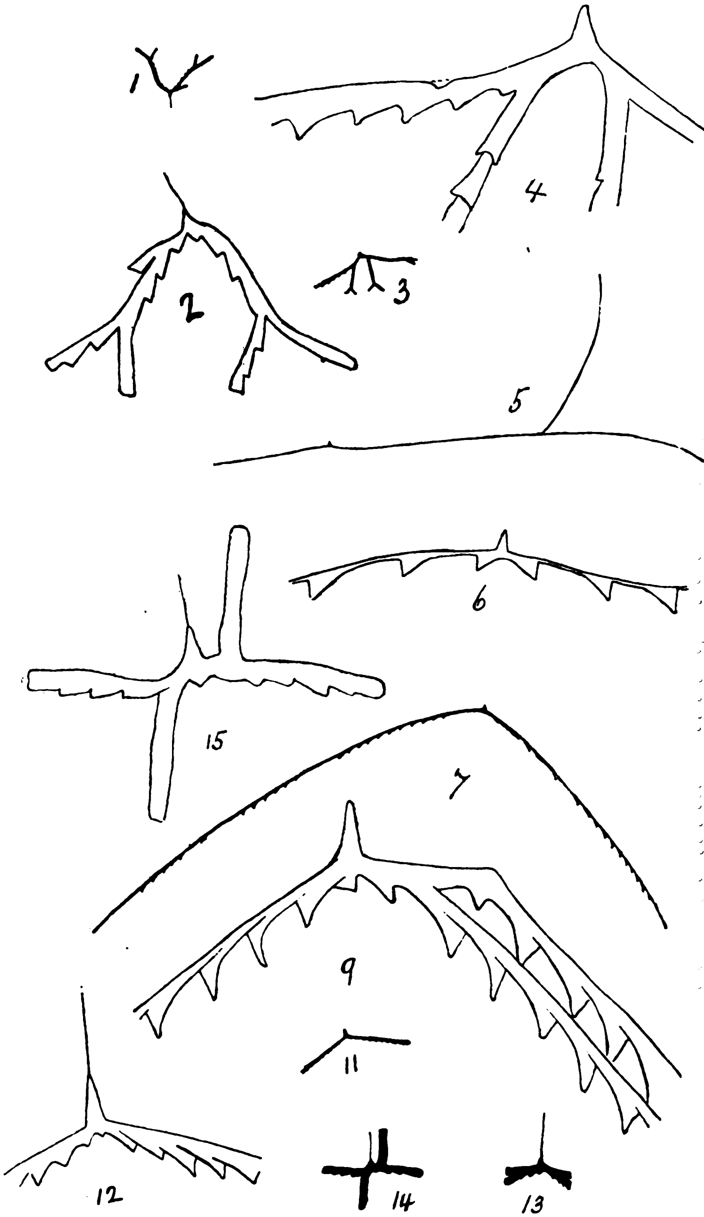
Taking all the facts into consideration I think that less violation will be done to generally accepted ideas by regarding Bryograptus as here ranging up into the Ordovician than by looking on the other genera as dating back to Cambrian times, and we are, I venture to think, justified in considering the graptolite bearing beds of Lancefield, which are dealt with in the present paper, as Ordovician rather than Cambrian.

EXPLANATION OF PLATES XVII., XVIII., AND XIX.

Fig. 1.—Bryograptus victoriae, n. sp., nat. size.
" 2. " " same specimen × 3½.
" 3.—Bryograptus clarki, n. sp., nat. size.
" 4. " " same specimen × 5.
" 5.—Leptograptus antiquus, n. sp., nat. size.
" 6. " " same specimen × 5 (Coll. G. Sweet).
" 7.—Didymograptus pritchardi, n. sp., nat. size.
" 8. " " nat. size; showing 3 branches.
" 9.—Didymograptus pritchardi, proximal part of No. 8 × 5.
" 10. " " proximal part of another specimen showing virgula.
" 11.—Didymograptus taylori, n. sp., nat. size.
" 12. " " proximal part × 3.

[1] Proc. Roy. Soc. Vic., N.S., viii., 1896, p. 52.

Fig. 13.—Tetragraptus decipiens, n. sp., nat. size.
„ 14. „ „ „ „ „
„ 15. „ „ same specimen as 14 × 3½.
„ 16. „ „ specimen with 6 branches, nat. size.
„ 17.—Tetragraptus decipiens, nat. size.
„ 18. „ „ „ „
„ 19. „ „ portion showing thecae × 5. (Figs. 17-19 Coll. G. B. Pritchard).
„ 20.—Clonograptus flexilis, J. Hall, × ½ (Coll. G. B. Pritchard).
„ 21.—Clonograptus rigidus, J. Hall, nat. size (Coll. G. B. Pritchard).
„ 22.—Clonograptus rigidus, thecae × 3½ (Coll. G. Sweet).
„ 23. „ „ *var* tenellus, Linnars., nat. size.
„ 24. „ „ „ „ „ „ „
„ 25. „ „ „ „ another specimen × 3½.
„ 26.—Phyllograptus sp. (Coll. G. Sweet).
„ 27.—Dictyonema macgillivrayi, T. S. Hall, thecae enlarged, (Coll. G. B. Pritchard).
„ 28, 29.—Dictyonema pulchellum, n. sp., nat. size.
„ 30. „ „ portion of 29 enlarged, showing thecae.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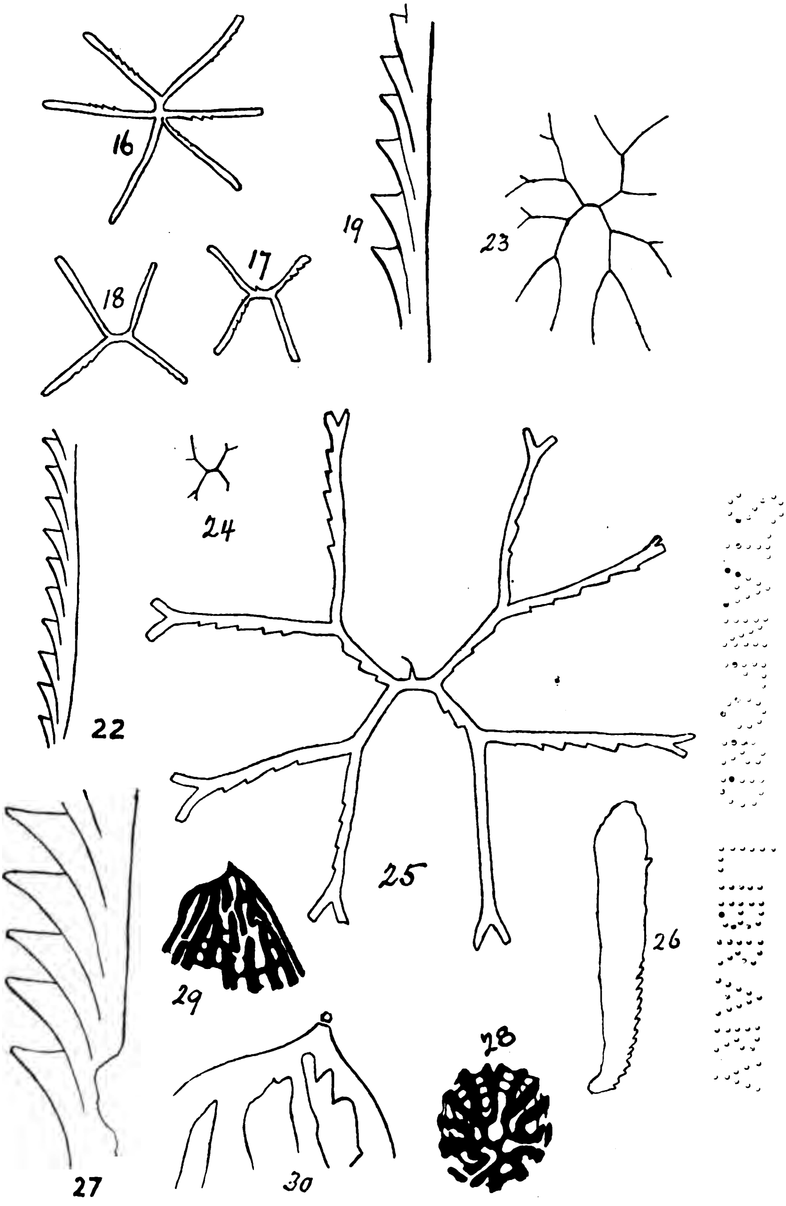
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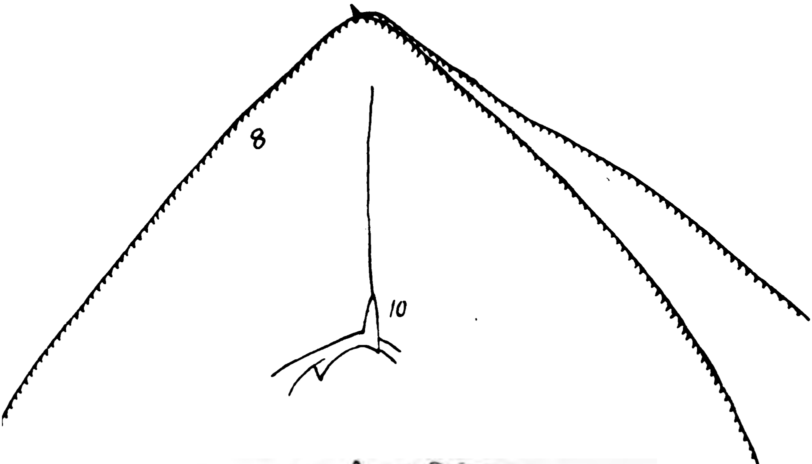

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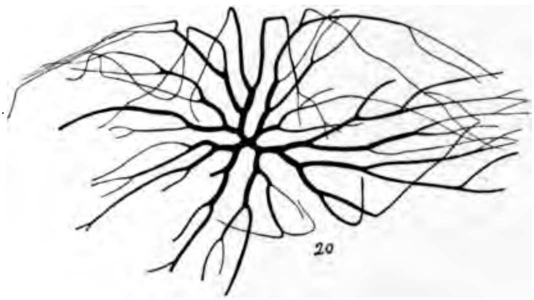

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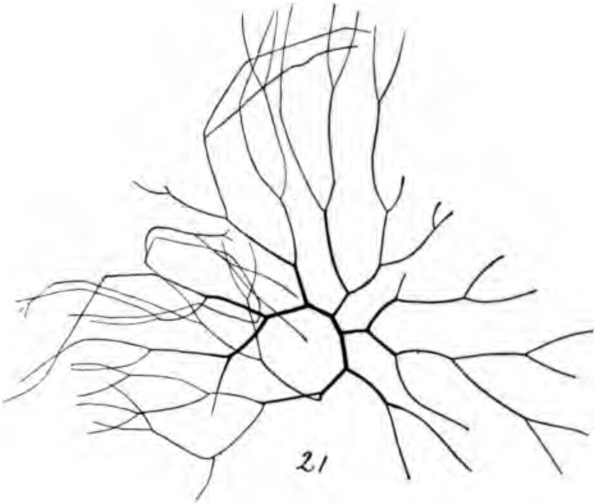

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Art. XIII.—*On Some New Species of Victorian Mollusca.*

By G. B. PRITCHARD and J. H. GATLIFF.

(With Plate XX.)

[Read 8th December, 1898.]

Marginella halli, sp. nov. (Pl. XX., Fig. 1).

Description.—Shell minute, somewhat tumidly ovate, white or sordid white in colour, of a relatively thick and solid build, and with a totally immersed spire. Aperture length gives nearly the greatest length of the shell on account of the ascending character of the outer lip, which reaches close to the axis of enrolment of the shell.

Outer lip thickened, smooth within, the thickening being continuous to the rather well marked enamelled pad of the inner lip at the posterior end, while at the anterior end it is continuous to the anterior columella plait.

Inner lip with a distinctly thickened enamel, and bearing anteriorly seven plaits, the three lower ones being most strongly developed, with occasionally a faint development of a slight intermediate ridge between the third and fourth and between the fourth and fifth.

Dimensions.—Length 2 mm.; breadth, 1·5 mm.

Locality.—Shoreham Beach, Western Port Bay.

Observations.—This species is named after Mr. T. S. Hall, M.A., who has rendered us much assistance in supplying accurate drawings of some of the species herein considered.

Marginella shorehami, sp. nov. (Pl. XX., Fig. 2).

Description.—Shell minute, ovate, translucent-white, smooth, with a short, obtuse, but distinctly developed spire consisting of about two to three whorls, and a somewhat regularly convex body-whorl, which bears very fine and regular milky-white markings parallel to the lines of growth, being just visible under a pocket lens.

Outer lip with accurate margin and relatively strongly thickened within, ascending well up the penultimate whorl, and forming a well developed, deep and broad posterior canal.

Inner lip furnished with about seven minute plaits, the anterior one being the strongest and forming an obliquely twisted plait, the successive posterior ones gradually diminishing in size until they become mere denticles near the posterior end of the aperture.

Dimensions.—Length, 2 mm.; breadth, 1·5 mm.

Locality.—Shoreham beach, Western Port Bay.

Marginella alternans, sp. nov. (Pl. XX., Fig. 3.)

Description.—Shell very minute, sub-cylindrical, or somewhat Cylichna-like, relatively thick, and opaque white, with a totally immersed spire, and a flatly-convex body-whorl. Aperture long, narrow, and ascending to the apex of the shell, and rather everted at the extremity. Outer lip thickened and well margined from the apex right down to the columella, where it coalesces with the anterior columellar plait. Columella bearing about four fairly strong oblique columellar plaits, the anterior being the strongest and most oblique, with three much fainter intermediate plaits between the stronger.

Outer lip apparently smooth within.

Dimensions.—Length, 1·5 mm.; breadth, 1 mm.

Locality.—Shoreham beach, Western Port Bay.

Observations.—The above specific name has been chosen on account of the alternately large and small plaits on the columella; and we are not aware of any other Australian species which is sufficiently closely allied to the present form to call for any special comment.

Marginella flindersi, sp. nov. (Pl. XX., Fig. 4.)

Description.—Shell very minute, narrowly ovate, thin, shining, white and translucent, with a totally immersed spire.

Body whorl long, narrow, and very slightly though regularly convex.

Aperture long, narrow, and arched from the extreme posterior to the extreme anterior, and at the posterior end is a deep and somewhat effuse canal.

Anterior end of aperture furnished on the columellar side with two oblique plaits, the one forming the anterior end of the columella being the strongest and most obliquely twisted.

Outer lip thin and smooth within.

Dimensions.—Length, 1·5 mm.; breadth, 1 mm.

Locality.—Shoreham beach, Western Port Bay.

Observations.—This species is very similar in general habit to Marginella (Persicula) nympha, Brazier, described from Watson Bay, Sydney; but, apart from other differences, attention may be particularly drawn to the distinct columellar folds and the thickened and denticulate outer lip.

Ancilla edithæ, n. sp. (Pl. XX., Fig. 5.)

Shell acuminately, elongately fusiform; fairly solid; of 7 whorls, including 2 nuclear; from the dorsal aspect the body whorl constitutes rather more than half of the entire length, and is very finely longitudinally and spirally striate.

Columellar callosity starting from a little below the centre of the aperture, and extending across the body and penultimate whorls; well defined, but not conspicuously prominent, it has a peculiarly finely corroded appearance.

An enamel band starts below the suture of the body whorl, and continues over the spire in a less pronounced manner. There are about five distinct, slightly punctured, encircling grooves on the penultimate and spiral whorls.

The uppermost basal groove commences at the columellar callosity, a little below the centre of the body whorl, and terminates in a very slight projection of the outer lip; after an interval this groove is followed by a second similar one, which has no projection on the lip, and terminates there a little above the notch; this groove is followed by a well defined ridge, which is somewhat concave at the lip; this is caused by the backward effuseness of the notch; then follow about six ridges crossing the arcuately twisted columella, the uppermost ridge terminating about the centre of the notch.

Aperture narrow lanceolate; outer lip acute, with a well defined sinus at its junction with the body whorl.

The shell is creamy white, with a brown band immediately above the upper basal groove; sometimes the coloration is

continuous, but the band usually consists of a series of blotches more or less coalescent; the enamelled band is coloured similarly, but in the form of dashes, which obliquely cross the suture and are there reversely bent, and continue thus round the spire, the intermediate marking between the bands on the body whorls are spirally zigzag, interrupted, and very light brown in colour.

Length, 18 mm.; breadth, 6 to 7 mm.; length of aperture, 9 mm.; maximum breadth, 3 mm.

Habitat.—Rosebud, Port Phillip, and Western Port.

Observations.—It is more narrowly acuminated, and the spire is proportionately more lengthy than in any other living species that we know of; its nearest ally is *A. lineata*, Kiener, for which species it has been mistaken; but it may be readily distinguished from it by its much more slender form and its numerous spiral grooves. We have two specimens from Spencer's Gulf, S.A., the prevailing colour of which is brown, and they are not so large as our shell; they have there been erroneously identified as *A. tricolour*, Gray, described as a Cape York species, now considered to be the young form of *A. australis*, Sowerby.

We have named this shell after Mr. Gatliff's eldest daughter Edith, who has given much assistance in searching for and sorting out the various species of shells.

Cancellaria maccoyi, n. sp. (Pl. XX., Fig. 6.)

Shell ovate; whorls 5½ rounded; suture impressed; spirally grooved, grooves on the body whorl numbering from 26 to 31, and on the penultimate whorl 12, the grooves are U-shaped, and following at fairly regular intervals from the base, until reaching about the centre of the body whorl, where the distance between them is greater, but becoming much closer at the shoulder, until the suture is reached; the area between the grooves is flat, and, under the lens, finely, irregularly, transversely striated.

Aperture narrowly ovate; outer lip acute, lirate within; columella usually triplicate, rarely quadriplicate.

Of a cream colour, with, on the body whorl, two broad light brown bands (visible in the interior), and a narrower one with a tendency to maculation immediately below the suture.

Dimensions.—Length of type, 19 mm.; breadth, 11 mm.; length of aperture, 11 mm.; breadth, 5 mm.

Locality.—Near Shoreham, Western Port (Gatliff).

Observations.—In general form this species is similar to *C. purpuriformis*, Valenciennes; the mouth is not as expanded as in *C. lævigata*, Sowerby, and it is not so solid as that shell.

We have named it after Sir Frederick McCoy, K.C.M.G., M.A., D.Sc., F.R.S., etc., who by kindly allowing us free access to the standard conchological works in the National Museum library, has so greatly assisted us in our endeavours to determine the identity and classification of our indigenous molluscan fauna.

Trichotropis gabrieli, n. sp. (Pl. XX., Fig. 7.)

Shell fragile, turbinately conical. Apex one and a half smooth embryonic whorls, succeeded by four others, the body whorl being much enlarged, and having two well defined spiral keels, starting near the centre of the outer lip, and continuing to the embryonic whorl, forming angles to the upper and lower greatest diameters of the body whorl; the upper keel on the body whorl being nearly twice as broad as the lower one, area between the two very slightly convex; regularly but indistinctly spirally striated; striæ continuing over the whole whorl, including the keels. Spiral sculpture of body whorl crossed by close faint lines of growth. Earlier spire whorls clathrate. Inner lip almost straight, slightly concave in the middle, somewhat everted. Outer lip semicircular, acute, simple. Widely and deeply umbilicated, almost to the apex; keeled throughout, keel continuing on the body whorl to the angulation of the anterior canal.

Colour, uniform chestnut within and without.

The epidermis is not ciliated.

Dimensions.—Length, 12 mm.; breadth, 10 mm.; length of aperture, 6 mm.; breadth, 5 mm.

Locality.—Swan Bay Channel, off Phillip Island, Western Port; Dredged in about 4 fathoms, two specimens (J. Gabriel).

Observations.—In general appearance it much resembles *T. quadricarinata*, A. Adams, but the spire is shorter and body whorl more ventricose.

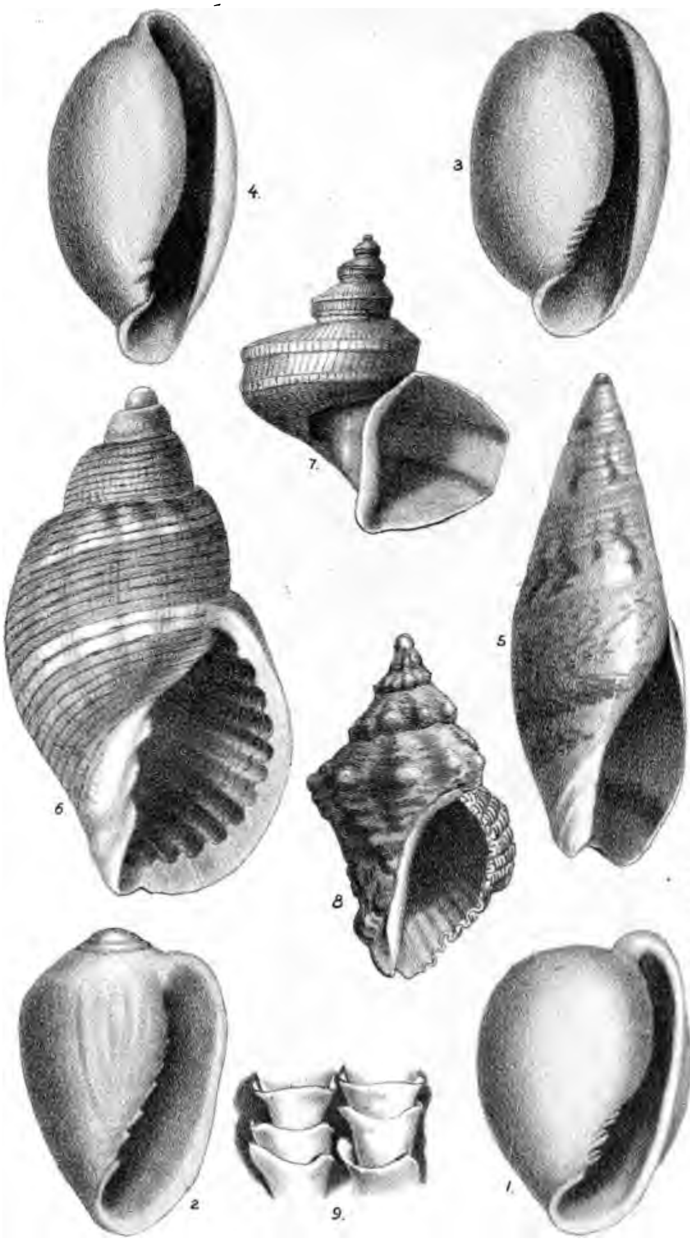
It is named after Mr. J. Gabriel, who discovered it.

EXPLANATION OF PLATE XX.

Fig. 1.—Marginella halli, sp. nov.
,, 2. ,, shorehami, sp. nov.
,, 3. ,, alternans, sp. nov.
,, 4. ,, flindersi, sp. nov.
,, 5.—Ancilla edithæ, sp. nov.
,, 6.—Cancellaria maccoyi, sp. nov.
,, 7.—Trichotropis gabrieli, sp. nov.
,, 8.—Coralliophila wilsoni, Pritchard and Gatliff.
,, 9. ,, ,, ornament.

All the figures are much enlarged.

For description of last species see Proc. Roy. Soc. Vic., n.s., vol. x., 1898, p. 140.



R. Wendel lith Melb.

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Art. XIV.—*Catalogue of the Marine Shells of Victoria.*

Part II.

By G. B. PRITCHARD and J. H. GATLIFF.

[Read 8th December, 1898.]

We published in December, 1897, Part I. of the present catalogue, which included 12 species of Cephalopoda, 11 species of Pteropoda, and 60 species of Gastropoda, making a total of 83 species.

The present part contains a total of 58 additional species of gastropods, comprising the following families:—Mitridæ, Marginellidæ, Olividæ, Columbellidæ, Cancellariidæ, and Terebridæ.

Family Mitridæ.

Genus **Mitra**, Lamarck, 1799.

Mitra australis, Swainson.

Mitra australis, Swainson. Zoological Illustrations, 1st series, pl. 18.

1833. Mitra melaleuca, Quoy and Gaimard. Astrolabe, vol. ii., p. 657, pl. 45, f. 26-27.

1841. Mitra melaleuca, Kuster. Conch. Cab., p. 142, No. 132, pl. 17e, f. 8.

1844. Mitra australis, Reeve. Conch. Icon., vol ii., pl. 16, f. 118.

1874. Mitra australis, Sowerby. Thes. Conch., vol. iv., p. 6, pl. 363, f. 182.

1874. Mitra kieneri, Sowerby. *Id.*, p. 32, pl. 368, f. 324.

1882. Mitra kieneri, Tryon. Man. Conch., vol iv., p. 124, pl. 36, f. 86.

1882. Mitra australis, Tryon. *Id.*, p. 126, pl. 37, f. 104, 105.

Hab.—Coast generally.

Obs.—It is worthy of note that in adult specimens the lip becomes remarkably expanded.

MITRA VINCENTIANA, Verco.

1896. Mitra vincentiana, Verco. T.R.S. S.A., p. 223, pl. 8, f. 3.

Hab.—Dredged 4 to 5 fathoms off Phillip Island, Western Port (J. Gabriel).

MITRA GLABRA, Swainson.

1821. Mitra glabra, Swainson. Exotic Conch., vol. i., pl. 24.

1833. Mitra buccinata, Quoy and Gaimard. Astrolabe, vol. ii., p. 653, pl. 45 *bis*, f. 14, 15.

1841. Mitra buccinata, Kuster. Conch. Cab., p. 136, pl. 17, f. 13.

1843. Mitra glabra, Lam. Anim. S. Vert. (ed. Desh.), vol. x., p. 348, sp. 90.

Mitra buccinata, Kiener. Icon. Coq. Viv., p. 32, pl. 11, f. 31.

1844. Mitra glabra, Reeve. Conch. Icon., vol. ii., pl. 6, f. 43.

1844. Mitra declivis, Reeve. *Id.*, f. 44.

1874. Mitra glabra, Sowerby. Thes. Conch., vol. iv., p. 7, pl. 355, f. 54.

1874. Mitra declivis, Sowerby. *Id.*, p. 7, pl. 365, f. 233, and pl. 366, f. 272.

1882. Mitra glabra, Tryon. Man. Conch., vol. iv., p. 117, pl. 34, f. 42.

1882. Mitra declivis, Tryon. *Id.*, pl. 34, f. 39 and 41.

Hab.—Western Port; Otway Coast; Port Fairy.

Obs.—Tryon considers that M. declivis, Reeve, is probably a deformed specimen of M. glabra, Sw., and we agree with him.

MITRA MELANIANA, Lamarck.

1811. Mitra melaniana, Lamarck. Ann. du Mus., vol. xvii., p. 212.

Mitra carbonaria, Swainson. Zoological Illustrations, 2nd ser., pl. 1.

1841. Mitra melaniana, Kuster. Conch. Cab., p. 44, No. 10, pl. 8, f. 7-8.

1844. Mitra nigra, Reeve (non Chemnitz). Conch. Icon., vol. ii., pl. 5, f. 33.

1874. Mitra nigra, Sowerby. Thes. Conch., vol. iv., p. 6, pl. 352, f. 4.

1882. Mitra melaniana, Tryon. Man. Conch., vol. iv., p. 127, pl. 37, f. 118.

Hab.—Point Roadknight; The Nobbies, Phillip Island; and Western Port.

Obs.—Reeve refers to Voluta nigra, Chemnitz, Conch., vol. x., p. 168. Tryon states: "Sowerby and Reeve call this species M. nigra, Chemnitz, but the figures in that scarcely-quotable author do not indicate this shell." As we cannot refer to the work by Chemnitz, we cite the shell as above.

MITRA BADIA, Reeve.

1844. Mitra badia, Reeve. P.Z.S. Lond., p. 181.

1844. Mitra badia, Reeve. Conch. Icon., vol. ii., pl. 20, f. 157.

1874. Mitra badia, Sowerby. Thes. Conch., vol. iv., pl. 363, f. 181.

1882. Mitra badia, Tryon. Man. Conch., vol. iv., p. 127, pl. 37, f. 112.

Hab.—Coast generally.

Obs.—The animal is opaque white. Specimens of what we consider to be a white variety of the above species have been obtained at Port Fairy by Rev. W. T. Whan. When living, it has a thin olive-brown epidermis.

MITRA ROSETTÆ, Angas.

1865. Mitra rosettæ, Angas. P.Z.S. Lond., p. 55, pl. 2, f. 6.

1874. Mitra rosettæ, Sowerby. Thes. Conch., vol. iv., p. 5, pl. 357, f. 339.

1882. Mitra rosettæ, Tryon. Man. Conch., vol, iv., p. 121, pl. 35, f. 64.

Hab.—Point Roadknight; Airey's Inlet; Apollo Bay.

Obs.—This species is closely allied to M. badia, but may be distinguished by its spiral whorls being more flattened, the body whorl more ventricose, and also by the lighter coloured longitudinal markings on the upper portion of the whorls. We have rarely found it on our coast, but M. badia is common.

MITRA PICA, Reeve.

1845. Mitra pica, Reeve. P.Z.S. Lond., p. 49.

1845. Mitra pica, Reeve. Conch. Icon., vol. ii., pl. 31, f. 247.

1874. Mitra pica, Sowerby. Thes. Conch., vol. iv., pl. 374, f. 522.

1882. Mitra pica, Tryon. Man. Conch., vol. iv., p. 125, pl. 37, f. 96.

Hab.—Western Port; Otway Coast; Warrnambool.

Obs.—Reeve does not give the habitat, Tryon names Cape of Good Hope, but in Marine Shells of South Africa, by G. B. Sowerby, 1892, it is not included.

MITRA SCITA, Woods.

1875. Mitra scita, T. Woods. P.R.S. Tas., p. 141.

1882. Mitra scita, Tryon. Man. Conch., vol. iv., p. 128.

Hab.—Portland.

Obs.—T. Woods observes "belonging to the series of which M. badia is a large representative," and describes it as pure deep brown; we have specimens from Cape Bridgewater with a light colour band below the suture, and irregular longitudinal whitish markings round about the centre of the whorls.

MITRA FRANCISCANA, T. Woods.

1876. Mitra franciscana, T. Woods. P.R.S. Tas., p. 133.

Hab.—Dredged off Phillip Island in about four fathoms (C. J. Gabriel).

Obs.—In size and general habit resembling M. badia, but differing in being strongly decussate in the sculpture.

Genus Turricula, Klein, 1753.

TURRICULA TASMANICA, T. Woods.

1875. Mitra tasmanica, T. Woods. P.R.S. Tas., p. 139.

1877. Mitra weldii, T. Woods. P.R.S. Tas., p. 31.

1878. Mitra tatei, Angas. P.Z.S. Lond., p. 861, pl. 54, f. 8.

1882. Mitra (Pusia) tatei, Tryon. Man. Conch., vol. iv., p. 183, pl. 54, f. 567.

Hab.—Coast generally.

Obs.—Columella quadriplicate.

Tryon states its length at three inches. Its length is about three-eights of an inch. In his description T. Woods states that there are two or three yellowish-white transverse bands. Specimens of our shell only display two transverse bands on the body whorl, and usually one only on the spiral whorls.

TURRICULA SCALARIFORMIS, T. Woods.

1875. Mitra scalariformis, T. Woods. P.R.S. Tas., p. 140.

1875. Mitra legrandi, T. Woods. *Id.*

1878. Mitra schomburgki, G. F. Angas. P.Z.S. Lond., p. 313, pl. 18, f. 12-13.

1882. Turricula (Costellaria) schomburgki, Tryon. Man. Conch., vol. iv., p. 173, pl. 51, f. 470.

Hab.—Coast generally.

Obs.—Columella triplicate.

Note.—Our two foregoing species have been wrongly identified with the following :—M. capensis, Dunker (M.S.), Reeve, Conch. Icon., pl. 33, f. 268; described as being transversely cancellated between the ribs; Volutomitra vincta, A. Adams, P.Z.S. Lond., 1854, p. 134, described as being smooth within the lip—Hab., Cape Natal; and M. rufocincta, A. Adams, P.Z.S. Lond., 1851, p. 134, described as impressed with transverse lines between the ribs, a feature only faintly discernible in our shells.

Family MARGINELLIDÆ.

Genus Marginella, Lamarck, 1801.

MARGINELLA MUSCARIA, Lamarck.

1822. Marginella muscaria, Lam. Anim. S. Vert., vol. x., p. 441.

Marginella muscaria, Kiener. Icon. Coq. Viv., pl. 3, f. 14.

1846. Marginella muscaria, Sowerby. Thes. Conch., vol. i., p. 376, pl. 75, f. 45-47.

1864. Marginella muscaria, Reeve. Conch. Icon., vol. xv., pl. 8, f. 29 a, b.

1883. Marginella formicula, Tryon (non Lam.). Man. Conch., vol. v., p. 23, pl. 6, f. 3.

Hab.—Gippsland Coast.

Obs.—This is the largest species found on Victorian shores.

Hutton in his Manual of New Zealand Mollusca, p. 202, states that his species Erato lactea may be the same as M. muscaria, and by a recent letter from Mr. Henry Suter of Christchurch, New Zealand, we are informed that this is the case.

MARGINELLA JOHNSTONI, Petterd.

1884. Marginella johnstoni, Petterd. Jour. of Conch., No. 33, p. 143.

Hab.—Brighton; San Remo; Sorrento.

Obs.—As Petterd remarks in his note to the description "approaching M. muscaria and M. tasmanica," it never attains to more than about one half of the length of the former species, and is constant in size and form. Sowerby remarks of M. muscaria "This species is remarkable for a tumidity near the reflected lip on the back of the last whorl." This feature is not prominent in M. johnstoni.

MARGINELLA TASMANICA, T. Woods.

1875. Marginella tasmanica, T. Woods. P.R.S. Tas., p. 28, No. 5.

1883. Marginella (Glabella) tasmanica, Tryon. Man. Conch., vol. v., p. 23, pl. 7, f. 6.

Hab.—San Remo; Port Albert.

Obs.—May be readily distinguished from M. johnstoni by its narrower form and more lengthy spire.

MARGINELLA FORMICULA, Lamarck.

1822. Marginella formicula, Lam. Anim. S. Vert., vol. x., p. 441.

1846. Marginella formicula, Sowerby. Thes. Conch., vol. i., p. 376, pl. 75, f. 41, 42.

1864. Marginella formicula, Reeve. Conch. Icon., vol. xv., pl. 8, f. 28, a, b.

1883. Marginella formicula, Tryon. Man. Conch, vol. v., p. 23, pl. 6, f. 2.

Hab.—Portland (Maplestone).

Obs.—This species is always plicate on the spire and on the shoulder of the body whorl, a feature never present in either of the three foregoing species.

MARGINELLA OVULUM, Sowerby.

1846. Marginella ovulum, Sowerby. Thes. Conch., vol. i., p. 401, pl. 78, f. 188.

1865. Marginella ovulum, Reeve. Conch. Icon., vol. xv., pl. 23. f. 129.

1867. Marginella (Cryptospira) ovulum, Angas. P.Z.S. Lond., p. 196.

1879. Marginella ovulum, Weinkauff. Conch. Cab. (ed. Küster), p. 116, sp. 171, pl. 22, f. 4.

1883. Marginella (Persicula) ovulum, Tryon. Man. Conch., vol. v., p. 40, pl. 11, f. 35.

1886. Marginella ovulum, Watson. Chall. Zool., vol. xv., p. 704.

Hab.—Off East Moncoeur Island, Bass Straits (Challenger).

MARGINELLA TURBINATA, Sowerby.

1846. Marginella turbinata, Sowerby. Thes. Conch., vol. i., p. 385, pl. 75, f. 70.

1865. Marginella turbinata, Reeve. Conch. Icon., vol. xv., pl. 22, f. 122.

1879. Marginella turbinata, Weinkauff. Conch. Cab. (ed. Küster), p. 86, sp. 115, pl. 16, f. 9 and 12.

1883. Marginella (Glabella) turbinata, Tryon. Man. Conch., vol. v., p. 23, pl. 7, f. 4.

1886. Marginella (Glabella) turbinata, Watson. Chall., vol. xv., p. 265.

Hab.—Port Phillip; Western Port; Portland.

Obs.—The specimens from the last named locality are unusually large.

MARGINELLA PYGMÆA, Sowerby.

1846. Marginella pygmæa, Sowerby. Thes. Conch., vol. i., p. 386, pl. 75, f. 78, 79.

1865. Marginella pygmæa, Reeve. Conch. Icon., vol. xv., pl. 23, f. 125.

1865. Marginella volutiformis, Reeve. *Id.*, pl. 24, f. 131.

1883. Marginella (Glabella) translucida, Tryon (non Sowerby). Man. Conch., vol. v., p. 26, pl. 8, f. 35.

1883. Marginella (Glabella) turbinata, Tryon (non Sowerby). *Id.*, p. 93, pl. 7, f. 5.

Hab.—Port Philip; Western Port; Portland.

Obs.—On comparing the figures and descriptions of M. pygmæa, Sowerby, and M. volutiformis, Reeve, we have been unable to separate them; Tryon, however, gets into considerable confusion in his treatment of these species, for he considers M. pygmæa, Sowerby, to be identical with M. translucida, Sowerby. The latter species is found in Port Jackson, and specimens before us show it to be quite distinct; also he regards M. volutiformis, Reeve, as a smooth variety of M. turbinata, Sowerby, but this cannot be entertained, unless the definition of species in the genus covers greater variation than is at present allowed.

Our specimens of M. pygmæa, Sowerby, show some slight variation in aspect on account of differences in the length of the spire, this, apparently, is the reason why Reeve describes M. volutiformis, as a new species.

Neither Sowerby nor Reeve gives a locality for their respective species, as they refer to the habitat as unknown.

MARGINELLA MINUTISSIMA, T. Woods.

1875. Marginella minutissima, T. Woods. P.R.S. Tas. p. 27.

1883. Marginella minutissima, Tryon. Man. Conch., vol. v., p. 56.

Hab.—Brighton.

Obs.—There is a specimen exhibited at the National Museum, Melbourne, as from the above locality.

MARGINELLA CYPRÆOIDES, T. Woods.

1877. Marginella (Cryptospira) cypræoides, T. Woods. P.R.S. Tas., p. 122.

1883. Marginella (Glabella) cypræoides, Tryon. Man. Conch., vol. v., p. 23.

Hab.—Sorrento (Ocean Beach); Portland (Agnes F. Kenyon); Shoreham Beach, Western Port.

MARGINELLA ALBIDA, Tate.

1878. Marginella albida, Tate. Proc. and Rep. Phil. Soc. of Adelaide, p. 87.

1878. Erato pellucida, T. Woods (non M. pellucida, Reeve). P.R.S. Tas., p. 35.
Marginella simsoni, Brazier, M.S.
1883. Marginella infans, Tryon (non Reeve). Man. Conch., vol. v., p. 232.

Hab.—Western Port, Port Fairy (Rev. W. T. Whan).

Obs.—The type of E. pellucida is in the National Museum, Melbourne.

MARGINELLA SHOREHAMI, Pritchard and Gatliff.

1898. Marginella shorehami, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. ii., p. 179, pl. 20, f. 2.

Hab.—Shoreham Beach, Western Port.

MARGINELLA HALLI, Pritchard and Gatliff.

1898. Marginella halli, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. ii., p. 179, pl. 20, f. 1.

Hab.—Shoreham Beach, Western Port.

MARGINELLA ALTERNANS, Pritchard and Gatliff.

1898. Marginella alternans, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. ii., p. 180, pl. 20, f. 3.

Hab.—Shoreham Beach, Western Port.

MARGINELLA FLINDERSI, Pritchard and Gatliff.

1898. Marginella flindersi, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. ii., p. 180, pl. 20, f. 4.

Hab.—Shoreham Beach, Western Port.

Obs.—The types of the four foregoing species are in Mr. Gatliff's private collection.

Family OLIVIDÆ.

Genus Oliva, Bruguière, 1789.

OLIVA AUSTRALIS, Duclos.

1835. Oliva australis, Duclos. Monog. du Genre, sp. 56, pl. 8, f. 3, 4.
1850. Oliva australis, Reeve. Conch. Icon., vol. 6, pl. 19, f. 52a, 52b.
1858. Strephona australis, Gray. Monog. Oliva, P.Z.S. Lond., p. 45, sp. 28.

1871. Oliva australis, Sowerby. Thes. Conch., vol. 4, p. 10, pl. 333, f. 85-88.

1878. Oliva australis, Weinkauff. Conch. Cab. (ed. Küster), p. 82, pl. 22, f, 3, 4.

1883. Oliva australis, Tryon. Man. Conch., vol. v., p. 85, pl. 32, fig. 19.

1886. Oliva (Ispidula) australis, Watson. Chall. Zool., vol. xv., p. 223.

Hab.—Port Fairy (Rev. W. T. Whan); Portland.

Obs.—The specimens we saw were obtained by the Rev. W. T. Whan at Port Fairy. The enamel of the shell and the markings were in good order, but there are certain indications which lead us to the conclusion that it is a very long time since they were in a live state, we think it possible that they may have been contained in material dredged in harbour improvements.

Genus **Olivella**, Swainson, 1835.

Olivella triticea, Duclos.

1835. Oliva triticea, Duclos. Monog. du. Genre, pl. 1, f. 3 and 4.

1850. Oliva triticea, Reeve. Conch. Icon., vol. vi., pl. 27, f. 82a, 82b.

1863. Oliva pardalis, Adams and Angas. P.Z.S. Lond., p. 422, pl. 37, f. 3.

1883. Olivella triticea, Tryon. Man. Conch., vol. v., p. 72, pl. 17, f. 42-44.

Hab.—Western Port.

Olivella nympha, Adams and Angas.

1863. Olivella nympha, Adams and Angas. P.Z.S. Lond., p. 422.

1878. Oliva (Olivella) nympha, Weinkauff. Conch. Cab. (ed. Küster) p. 150, pl. 38, f. 10.

1883. Olivella nympha, Tryon. Man. Conch., vol. v., p. 72, pl. 17, f. 46.

1886. Oliva (Olivella) nympha, Watson Chall. Zool., vol. xv., p. 225.

Hab.—Western Port; Port Phillip; Portland (Maplestone).

OLIVELLA LEUCOZONA, Adams and Angas

1863. Olivella leucozona, Adams and Angas. P.Z.S. Lond., p. 422, pl. 37, f. 23.

1867. Olivella leucozona, G. F. Angas. *Id.*, p. 192.

1878. Oliva (Olivella) leucozona, Weinkauff. Conch. Cab. (ed. Küster) p. 159, pl. 39, f. 13.

1883. Oliva leucozona, Tryon. Man. Conch., vol. v., p. 72, pl. 17, f. 45.

1886. Oliva (Olivella) leucozona, Watson. Chall. Zool., vol. xv., p. 225.

Hab.—Shoreham, Western Port; San Remo; Lorne.

Genus **Ancilla**, Lamarck, 1799.

ANCILLA LINEATA, Kiener.

Ancillaria lineata, Kiener. Icon. Coq. Viv., p. 16, pl. 3, f. 2.

1859. Ancillaria lineata, Sowerby. Thes. Conch., vol. iii., pl. 3, f. 57, 58.

1864. Ancillaria lineata, Reeve. Conch. Icon., vol. xv., pl. 8, f. 25, a, b.

1883. Ancillaria marginata, Tryon (non Kiener). Man. Conch., vol. 5, p. 96, pl. 39, fig. 46.

Hab.—Portland (Maplestone).

ANCILLA MARGINATA, Lamarck.

1810. Ancillaria marginata, Lamarck. Ann. du Mus., vol. xvi., p. 304.

1822. Ancillaria marginata, Lamarck. Anim. S. Vert., vol. x., p. 591.

1830. Ancillaria marginata, Sowerby. Species Conch., pt. i., f. 40-43

1859. Ancillaria marginata, Sowerby. Thes. Conch., vol. iii., p. 64, pl. 3, f. 46, 47.

1864. Ancillaria marginata, Reeve. Conch. Icon., vol. xv., pl. 3, f. 8, a, b.

1876. Ancillaria tasmanica, T. Woods. P.R.S. Tas., p. 135.

1883. Ancillaria marginata, Tryon. Man. Conch., vol. v., p. 96, pl. 39, f. 44.

Hab.—Coast generally.

Obs.—We have a large series of specimens before us of different sizes and varying stages of growth, on some of which the dark brown markings are absent. Tryon considers that A. monilifera, Reeve, A. lineata, Kiener, A. oblonga, Sowerby, and A. obesa, Sowerby, are all young shells of A. marginata. With this we cannot agree. We have carefully examined and compared specimens of all of these species excepting A. obesa, and consider them to be valid species.

ANCILLA OBLONGA, Sowerby.

1830. Ancillaria oblonga, Sowerby. Species Conch., pt. i., p. 7, f. 38, 39.

1859. Ancillaria oblonga, Sowerby. Thes. Conch., vol. iii, p. 65, pl. 213, f. 42, 43.

1864. Ancillaria oblonga, Reeve. Conch. Icon., vol. xv., pl. 8, f. 24, a, b.

1883. Ancillaria marginata, Tryon (non Lamarck). Man. Conch., vol. v., p. 96, pl. 39, f. 47.

1886. Ancilla (Amalda) oblonga, Watson. Chall. Zool., vol. xv., p. 231.

Hab.—Off East Moncoeur Island, Bass Strait, 38 fathoms (Challenger).

ANCILLA PETTERDI, Tate.

1886. Ancillaria obtusa, Petterd (non Swainson). P.R.S. Tas., p. 342.

1893. Ancillaria obesula, Tate (non Deshayes). In Adcock's Hand List S.A. Moll., p. 5.

1893. Ancillaria obesula, Tate (non Deshayes). P.R.S. S.A., p. 199.

1893. Ancillaria petterdi, Tate. P.R.S. S.A., p. 199.

Hab.—Apollo Bay and Otway Coast.

ANCILLA EDITHÆ, Pritchard and Gatliff.

1898. Ancilla edithæ, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. ii., p. 181, pl. 20, f. 5.

Hab.—Rosebud, Sorrento, Port Phillip.

Obs.—The type is in Mr. Gatliff's private collection.

Family Columbellidæ.

Genus **Columbella**, Lamarck, 1799.

Columbella semiconvexa, Lamarck.

1822. Buccinum semiconvexum, Lamarck. Anim. S. Vert., 2nd ed., vol. x., p. 171.
1847. Columbella semiconvexa, Sowerby. Thes. Conch., vol. i., pl. 38, f. 103, 104.
1858. Columbella semiconvexa, Reeve. Conch. Icon., vol. xi., pl. 18, f. 95a. b.
1859. Columbella strigata, Reeve. *Id.*, pl. 25, f. 154.
1859. Columbella rosacea, Reeve. *Id.*, pl. 29, f. 183.
1865. Columbella yorkensis, Crosse. Jour. d. Conch., p. 55, pl. 2, f. 6.
1883. Columbella semiconvexa, Tryon. Man. Conch., vol. v., p. 125, pl. 48, f. 87-89.
1883. Columbella broderipii, Tryon (non Sowerby). *Id.*, p. 114, pl. 46, f. 26.
1892. Columbella (Mitrella) semiconvexa, Kobelt. Conch. Cab. (ed. Kuster), p. 81-83, pl. 11, f. 10-18 (not f. 13).

Hab.—Coast generally.

Obs.—The commonest species found on our shores. It differs greatly in size; in length from 21 mm. to 8 mm., and in breadth from 7 mm. to 3 mm.; specimens measuring 16 mm. in length sometimes are met with that attain to the maximum of 7 mm. in breadth; and the shell varies in colour, from a uniform white to brown with darker markings. This species in South Australia is generally somewhat narrower in form, and in New South Wales does not attain to such a large size as elsewhere.

We cannot follow G. F. Angas (P.Z.S. Lond., 1867, p. 194) in accepting C. saccharata, Reeve, Conch. Icon., vol. xi., pl. 29, f. 187, as a synonym, as the figure of that species is of a more acuminate shell than is exhibited by any specimen of the many hundreds that we have examined from Victoria, New South Wales or South Australia.

We refer to C. rosacea as a synonym, but the specimen figured is an unusually small one of C. semiconvexa, and the figure shows an abnormal development of the upper denticle.

Tryon includes in the synonymy C. saccharata, Reeve, C. lutea, Quoy, C. polita, Reeve, and C. miltostoma, Woods, but we cannot agree with him.

COLUMBELLA AUSTRINA, Gaskoin.

1851. Columbella austrina, Gaskoin. P.Z.S. Lond., p. 9.
1858. Columbella austrina, Reeve. Conch. Icon., vol. xi., pl. 19, f. 100.
1863. Columbella infumata, Crosse. Jour. d. Conch., p. 84, pl. 1, f. 3.
1883. Columbella (Nitidella) infumata, Tryon. Man. Conch., vol. v., p. 117, pl. 47, f. 45.
1883. Columbella (Mitrella) austrina, Tryon. *Id.*, p. 126, pl. 49, f. 99.
1892. Columbella (Alia?) infumata, Kobelt. Conch. Cab. (ed. Kuster), p. 105, No. 83, pl. 15, f. 14.
1893. Columbella (Mitrella) austrina, Kobelt. Conch. Cab. (ed. Kuster), p. 170, No. 165, pl. 23, f. 12.

Hab.—Lorne; Western Port; Port Phillip; Corio Bay; Puebla Coast; Airey's Inlet; Apollo Bay.

Obs.—This species has been wrongly identified as C. impolita, Sowerby, Thes. Conch., vol. i., p. 132, pl. 39, f. 127, which it much resembles in colouration, but is not nearly so large. C. impolita, is flatter in the whorls, and in the specimens before us from Japan the earlier spiral whorls are distinctly longitudinally plicate, a feature never present in our species.

COLUMBELLA MENKEANA, Reeve.

1843. Buccinum acuminatum, Menke (non C. acuminata, Nuttall). Moll. Nov. Holl., p. 20, No. 87.
1858. Columbella menkeana, Reeve. Conch. Icon., vol. xi., pl. 14, f. 69, a, b.
1876. Columbella xavierana, T. Woods. P.R.S. Tas., p. 134.
1883. Columbella (Mitrella) menkeana, Tryon. Man. Conch., vol. v., p. 120, pl. 48, f. 66.
1883. Columbella (Mitrella) xavierana, Tryon. *Id.*, p. 137, pl. 51, f. 50.

1892. Columbella (Mitrella) menkeana, Kobelt. Conch. Cab. (ed. Kuster), p. 110, No. 89, pl. 16, f. 12-14.

1895. Columbella (Mitrella) xavieriana, Kobelt. Conch. Cab. (ed. Kuster), p. 213, No. 238, pl. 29, f. 10.

Hab.—Western Port; Otway Coast.

Obs.—The shell named C. xavierana, T. Woods, is the variety on which the dark markings "assume the form of undulating chesnut longitudinal broad lines of colour, which under the lens are sometimes seen to be flecked with white." This variety has been wrongly identified as C. tayloriana, Reeve, a broader New South Wales species. Occasionally the shell has a narrow continuous encircling brown band, which commences on the centre of the outer lip and continues round the spire immediately above and adjoining the suture.

COLUMBELLA LINCOLNENSIS, Reeve.

1859. Columbella lincolnensis, Reeve. Conch. Icon., vol. xi., pl. 29, f. 184, a, b.

1867. Columbella (Mitrella) lincolnensis, Angas. P.Z.S. Lond., p. 195.

1883. Columbella (Mitrella) lincolnensis, Tryon. Man. Conch., vol. v., p. 120, pl 48, f. 65.

1893. Columbella (Atilia) lincolnensis, Kobelt. Conch. Cab. (ed. Kuster), p. 134, No. 118, pl. 19, f. 15-16.

Hab.—Western Port; Port Phillip; Otway Coast.

Obs.—Victorian specimens are usually more robust in form than the type from South Australia. In general habit it closely resembles C. menkeana, but is much smaller.

COLUMBELLA LINEOLATA, Tryon.

1871. Columbella maculosa, Pease (non Sowerby). Amer. Jour. Conch., vol. vii., p. 22.

1876. Columbella dermestoides, Angas (non Kiener). P.Z.S. Lond., p. 195.

1877. Columbella lineolata, Brazier. P.Z.S. N.S.W., vol. i., p. 231.

1883. Columbella (Mitrella) lineolata, Tryon. Man. Conch., vol. v., p. 138, pl. 51, f. 53.

Hab.—Portland; Lorne; Western Port; Port Phillip.

Obs.—This shell was first described by Pease as C. maculosa, a name pre-occupied by Sowerby. Angas then wrongfully identified it as C. dermestoides, Kiener, an allied species from the West Indies. Then Brazier incidentally drew attention to the error of Angas, and said it was C. lineolata, Pease; in this he made a mistake, as Pease never named a shell C. lineolata, but described one as C. lineata, which was not figured, and the description does not tally with the shell under discussion; we therefore must cite the species as C. lineolata, Tryon. Tryon's figure is not a good one, and appears to have been taken from a poor small specimen.

COLUMBELLA MILTOSTOMA, T. Woods.

1876. Columbella miltostoma, T. Woods. P.R.S. Tas., p. 134.

1883. Columbella (Mitrella) semiconvexa, Tryon (non Lamarck). Man. Conch., vol. v., p. 125, pl. 48, f. 93.

1892. Columbella (Mitrella) semiconvexa, Kobelt (non Lamarck). Conch. Cab., p. 82.

1892. Columbella (Mitrella) unisulcata, Kobelt. Conch. Cab. (ed. Kuster), p. 119, No. 100, pl. 17, f. 15, 16.

Hab.—Flinders, San Remo.

Obs.—Tryon considers this shell to be a minor variety of C. semiconvexa, Lamarck. He is wrong. The foregoing species, C. lineolata, is in general habit nearly related; but it may be distinguished therefrom by a continuous encircling groove immediately below the suture, by its lighter coloration, and different style of marking; these diversities are constant. Tryon's figure is a poor one and the delineation has not shown the groove alluded to; it is not a deep one, but always present, and he may be excused, as Tenison Woods does not mention it in his description of the shell. Dr. Kobelt follows Tryon in regarding C. miltostoma, T. Woods as a variety of C. semiconvexa, Lamarck, yet the actual species we regard as T. Woods' is described by him as new, clearly showing that T. Woods' species had not been correctly identified.

COLUMBELLA ANGASI, Brazier.

1865. Columbella interrupta, Angas (non Gaskoin). P.Z.S. Lond., p. 56, pl. 2, f. 9, 10.

1871. Columbella angasi, Brazier. *Id.*, p. 322.

1883. Columbella (Mitrella) angasi, Tryon. Man. Conch., vol. v., p. 128, pl. 49, f. 11.

1895. Columbella (Mitrella) angasi, Kobelt. Conch. Cab. (ed. Kuster), p. 210, No. 233, pl. 29, f. 4.

Hab.—Western Port; Port Phillip; Outer Geelong Harbour.

COLUMBELLA TENISONI, Tryon.

1875. Columbella minuta, T. Woods (non Gould). P.R.S. Tas., p. 152.

1883. Columbella (Mitrella) tenisoni, Tryon. Man. Conch., vol. v., p. 128, pl. 49, f. 10.

1895. Columbella (Mitrella) tenisoni, Kobelt. Conch. Cab. (ed. Kuster), p. 210, No. 232.

Hab.—Western Port.

COLUMBELLA TENUIS, Gaskoin.

1851. Columbella tenuis, Gaskoin. P.Z.S. Lond., p. 2.

1851. Columbella pulla, Gaskoin. *Id.*, p. 6.

1858. Columbella pulla, Reeve. Conch. Icon., vol. xi., pl. 19, f. 106.

1859. Columbella tenuis, Reeve. *Id.*, pl. 35, f. 224.

1859. Columbella nux, Reeve. *Id.*, pl. 35, f. 227.

1875. Columbella badia, T. Woods. P.R.S. Tas., p. 151.

1875. Columbella roblini, T. Woods. *Id.*, p. 151.

1883. Columbella (Mitrella) tenuis, Tryon. Man. Conch., vol. v., p. 127, pl. 49, f. 3.

1883. Columbella (Mitrella) pulla, Tryon. *Id.*, pl. 49, f. 4-6.

1892. Columbella (Mitrella) pulla, Kobelt. Conch. Cab. (ed. Kuster), p. 106, No. 84, pl. 15, f. 15-18.

1892. Columbella (Mitrella) tenuis, Kobelt. Conch. Cab. (ed. Kuster), p. 127, No. 109, pl. 18, f. 15-16.

Hab.—Western Port; Port Philip; Otway Coast.

Obs.—Type described from a large young shell, with broad, flamed, brown markings, and in which the outer lip has not developed the internal denticles; in adult specimens these are

pronounced, and the columella exhibits the same character, but the denticulations there are not so rounded or prominent. Specimens of this species, as of others, are sometimes found of a creamy white with a narrow encircling brown band at the suture. In dark coloured shells the white columella, mentioned in Gaskoin's description as distinctive, is very rarely absent.

COLUMBELLA TENEBRICA, Reeve.

1859. Columbella tenebrica, Reeve. Conch. Icon., vol. xi., pl. 31, f. 204

1883. Columbella (Mitrella) tenebrica, Tryon. Man. Conch., vol. v., p. 128, pl. 49, f. 9.

1892. Columbella (Mitrella) tenebrica, Kobelt. Conch. Cab. (ed. Kuster), p. 119, No. 99, pl. 17, f. 14.

Hab.—Western Port.

Obs.—Reeve remarks, "allied to C. pulla in form and general appearance, but it will be found on examination to be obscurely striped, while it has not the white columella distinctive of that species." We think it probable that C. velata, Reeve, Conch. Icon., vol. xi., pl. 28, f. 182, should be united with C. tenebrica, but Reeve does not give the dimensions of C. velata, and the other species figured on plate 28 are much enlarged, this fact is not stated and the usual lines indicating the length of the shells are omitted.

COLUMBELLA NUBECULATA, Reeve.

1859. Columbella nubeculata, Reeve. Conch. Icon., vol. xi., pl. 37, f. 234.

1878. Columbella dictua, T. Woods. P.R.S. Tas., p. 34.

1883. Columbella (Mitrella) dictua, Tryon. Man. Conch., vol. v., p. 126, pl. 48, f. 96.

1883. Columbella (Mitrella) roblini, Tryon (non T. Woods). *Id.*, p. 128, pl. 49, f. 7.

1883. Columbella (Mitrella) nubeculata, Tryon. *Id.*, p. 140, pl. 51, f. 55.

1892. Columbella (Mitrella) nubeculata, Kobelt. Conch. Cab. (ed. Kuster), p. 113, No. 92, pl. 16, f. 18.

1893. Columbella (Mitrella) vincta, Tate. T.R.S. S.A., vol. xvii., p. 190, pl. 1, f. 11.

1895. Columbella (Mitrella) dictua, Kobelt. Conch. Cab. (ed. Kuster), p. 209, No. 230, pl. 29, f. 1.

Hab.—Western Port; Port Phillip; Portland.

Obs.—The colouration of this shell displays more variation than any species that we know. Reeve remarks, "rather obscurely clouded in respect of colouring which inclines towards the base to form a fine network." In C. dictua this network continues over the whole shell, but assumes the form of zig-zag spiral lines; when the markings take the form of an encircling band it may be present on two of the apical whorls only, the rest of the shell being white, or it may continue round all the whorls, the C. vincta being marked in this latter manner; or the lines and the reticulations may be present in the same shell; or it may be all white, salmon-red, or blackish-brown, or principally lavender or yellow; or any of these may be the body colour, with darker markings forming encircling spots, bands, irregular maculations, longitudinal flamings, or fine lines; but the form is fairly constant, the size varying from: length, 10 mm.; breadth, 4·5 mm., to length, 6 mm.; breadth, 2·4 m.m.

Tryon rightly considers C. roblini, T. Woods, to be a synonym of C. pulla, Gaskoin, but the shell he figures, quoted above, does not answer to Woods' description, but is one of the many varieties of C. nubeculata.

COLUMBELLA ATTENUATA, Angas.

1871. Columbella attenuata, Angas. P.Z.S. Lond., p. 14, pl. 1, f. 4.

1883. Columbella (Atilia) attenuata, Tryon. Man. Conch., vol. v., p. 151, pl. 53, f. 18.

1884. Terebra beddomei, Petterd. Jour. of Conch., vol. iv., No. 28, p. 142.

1896. Columbella (Atilia) attenuata, Kobelt. Conch. Cab. (ed. Kuster), p. 220, No. 251, pl. 30, f. 6.

Hab.—Barwon Heads (T. S. Hall).

COLUMBELLA BRUNNEA, Brazier.

1898. Columbella (Mitrella) brunnea, Brazier. P.L.S. N.S.W., p. 271.

Hab.—San Remo; Ocean Beach, West Head, Flinders.

Obs.—The type is a brown shell, but we also have specimens that are entirely white, and others that have a circle of brown spots below the suture.

COLUMBELLA ATKINSONI, T. Woods.

1875. Mangelia atkinsoni, T. Woods. P.R.S. Tas., p. 141.

1877. Columbella speciosa, Angas. P.Z.S. Lond., p. 35, pl. 5, f. 3.

1883. Columbella (Seminella) speciosa, Tryon. Man. Conch., vol. v., p. 171, pl. 57, f. 24.

1896. Columbella (Seminella) speciosa, Kobelt. Conch. Cab. (ed. Kuster), p. 237, No. 281, pl. 32, f. 7.

Hab.—Western Port; Outer Geelong Harbour.

COLUMBELLA COMINELLÆFORMIS, Tate.

1892. Columbella cominellæformis, Tate. T.R.S. S.A., vol. xv., p. 126, pl. 1, f. 8.

Hab.—Western Port.

Obs.—We are rather doubtful as to whether this shell is correctly classed generically, species of Columbella that are allied to this in general form, usually have the outer lip thickened and dentate or lirate within; in the species under notice the lip is always thin, acute, and simple. In general habit the shell is closely allied to Mangelia anomala, Angas, but it does not attain to so large a size.

NOTE.—The shells of this genus are abundant on our coast, those of the sub-genus Mitrella especially so, and it is difficult to define the species, the colouration is so variable that it generally is of very little specific value. The species C. austrina and C. lineolata are exceptions.

Family CANCELLARIIDÆ.

Genus **Cancellaria**, Lamarck, 1799.

CANCELLARIA GRANOSA, Sowerby.

1841. Cancellaria granosa, Sowerby. Conch. Illustr., p. 2, No. 15, pl. 10, f. 17.

1849. Cancellaria granosa, Sowerby. Thes. Conch., vol. ii., p. 443, pl. 95, f. 58, 59.

1885. Cancellaria granosa, Tryon. Man. Conch., vol. vii., p. 68, pl. 2, f. 16.

1887. Cancellaria granosa, Kobelt. Conch. Cab. (ed. Kuster), p. 48, No. 42, pl. 14, f. 5, 6.

Hab.—Port Phillip; Western Port.

Obs.—With the figures accompanying the original description Sowerby's figure No. 16 was wrongly included, that being C. undulata, and he drew attention to the error in his Thesaurus Conchyliorum, hence the error of some Australian Conchologists.

CANCELLARIA UNDULATA, Sowerby.

1841. Cancellaria granosa, Sowerby. Conch. Illustr., pl. 10, f. 16.

1848. Cancellaria undulata, Sowerby. P.Z.S. Lond., p. 136.

1849. Cancellaria undulata, Sowerby. Thes. Conch., vol. ii., p. 443, pl. 92, f. 12, and pl. 95, f. 79.

1856. Cancellaria undulata, Reeve. Conch. Icon., vol. x., pl. 3, f. 9.

1883. Cancellaria undulata, Brazier. P.L.S. N.S.W., p. 226.

1885. Cancellaria spengleriana, Tryon (non Deshayes). Man. Conch., vol. vii., p. 67, pl. 1, f. 4, 5.

1886. Cancellaria undulata, Watson. Chall. Zool., vol. xv., p. 273.

1887. Cancellaria undulata, Kobelt. Conch. Cab. (ed. Kuster), p. 40, No. 35, pl. 13, f. 1-3.

Hab.—San Remo; Port Fairy.

CANCELLARIA LÆVIGATA, Sowerby.

1841. Cancellaria lævigata, Sowerby. Conch. Illustr., p. 3, No. 25, pl. 11, f. 24.

1849. Cancellaria lævigata, Sowerby. Thes. Conch., vol. ii., p. 448, pl. 92, f. 16, and pl. 96, f. 81.

1885. Cancellaria (Euclia) lævigata, Tryon. Man. Conch., vol. vii., p. 74, pl. 3, f. 52.

1887. Cancellaria lævigata, Kobelt. Conch. Cab. (ed. Kuster), p. 49, No. 43, pl. 14, f. 7, 8.

Hab.—Coast Western District; Western Port.

Obs.—In the National Museum, Melbourne, there is a shell from Tasmania labelled C. tasmanica, T. Woods. This is the above species, but as we have not had access to the type, we have deferred including it in the synonymy owing to the meagreness of the description and absence of any illustration.

CANCELLARIA SPIRATA, Lamarck.

Cancellaria spirata, Lamarck. Anim. S. Vert., vol. ix., p. 408.

1839. Cancellaria spirata, Lamarck. Anim. S. Vert., (Deshayes and Edwards, 3rd edit.), vol. iii., p. 645.

1841. Cancellaria spirata, Sowerby. Conch. Illustr., p. 4, No. 26, pl. 11, f. 25.

1848. Cancellaria excavata, Sowerby. P.Z.S. Lond., p. 137.

1849. Cancellaria spirata, Sowerby. Thes. Conch., vol. ii., p. 449, No. 34, pl. 93, f. 22.

1849. Cancellaria excavata, Sowerby. *Id.*, No. 35, f. 18.

1885. Cancellaria (Trigonostoma) spirata, Tryon. Man. Conch., vol. vii., p. 77, pl. 4, f. 71, and pl. 5, f. 72.

1887. Cancellaria spirata, Kobelt. Conch. Cab. (ed. Kuster), p. 25, No. 20, pl. 6, f. 9, 10.

1887. Cancellaria excavata, Kobelt. Conch. Cab. (ed. Kuster), p. 92, No. 100. Figure in text.

Hab.—Western Port; Portland; Airey's Inlet.

CANCELLARIA MACCOYI, Pritchard and Gatliff.

1898. Cancellaria maccoyi, Pritchard and Gatliff. P.R.S. Vic., vol. xi., n.s., pt. 2, p. 182, pl. 20, f. 6.

Hab.—Western Port

Obs.—The type of this species is in Mr. Gatliff's private collection.

Family TEREBRIDÆ.

Genus **Terebra**, Adamson, 1757.

TEREBRA USTULATA, Deshayes.

1857. Terebra ustulata, Deshayes, Jour. d. Conch., p. 97, pl. 3, f. 12.

1859. Terebra ustulata, Deshayes. P.Z.S. Lond., No. 96, p. 294.

1860. Terebra ustulata, Reeve. Conch. Icon., vol. xii., pl. 17, f. 73.

1885. Terebra ustulata, Tryon. Man. Conch., vol. vii., p. 18, pl. 4, f. 59.

Hab.—Portsea. Western Port.

Obs.—The original figure is coloured brown; our shells are usually fleshy white, and the lower half of the body whorl and apex coloured brown.

TEREBRA KIENERI, Deshayes.

1859. Terebra kieneri, Deshayes. P.Z.S. Lond., No. 97, p. 294.

1860. Terebra kieneri, Reeve. Conch. Icon., vol. xii., pl. 21, f. 110.

1885. Terebra spectabilis, Tryon (non Hinds). Man. Conch., vol. vii., p. 18, pl. 4, f. 56.

Hab.—Port Phillip; Western Port.

Obs.—The longitudinal ribs in this species are about twice as numerous as in T. ustulata; in general habit they are similar.

TEREBRA BRAZIERI, Angas.

1871. Terebra brazieri, Angas. P.Z.S. Lond., p. 16, pl. 1, f. 15.

1885. Terebra brazieri, Tryon. Man. Conch., vol. vii., p. 35, pl. 10, f. 93.

Hab.—Western Port.

TEREBRA BICOLOR, Angas.

1867. Acus (Abretia) bicolor, Angas. P.Z.S. Lond., p. 111, pl. 13, f. 7.

1885. Terebra fictilis, var., Tryon (non Hinds). Man. Conch., vol. vii., p. 25, pl. 7, f. 11.

1886. Terebra (Myurella) bicolor, Watson. Chall. Zool., vol. xv., p. 380.

Hab.—Portsea; Western Port.

Obs.—Tryon considers this very well-marked species to be but a variety of T. fictilis, Hinds, with this we cannot agree; even the figures given by him fail to show that such is the case.

TEREBRA ALBIDA, Gray.

1834. Terebra albida, Gray. P.Z.S. Lond., p. 63.

1844. Terebra albida, Sowerby. Thes. Conch., vol. i., p. 158, pl. 43, f. 56.

1860. Terebra albida, Reeve. Conch. Icon., vol. xii., pl. 17, f. 79.

1885. Terebra albida, Tryon. Man. Conch., vol. vii., p. 11, pl. 12, f. 29.

Hab.—Portsea, Port Phillip.

Obs.—Originally described as being from New South Wales, Port Phillip at that time forming a portion of that colony.

ART. XV.—*A Contribution to the Petrology of Kerguelen Island.*

BY EVELYN G. HOGG, M.A.

[Read 8th December, 1898.]

The rocks described in the following paper were collected by Mr. Robert Hall of Surrey Hills, Melbourne, who visited Kerguelen Island in a whaling vessel in January, 1898. They were obtained from four localities, namely, Howe Island, Greenland Harbour, Royal Sound, and "Cat's Ears." Rocks from the three first-named places have been described either by Professor J. Roth,[1] or by Professor A. Renard.[2] Under these circumstances only brief references will be made to rocks and localities which have been previously dealt with. Though no information can be given by the writer as to the field relations of the rocks described below, the specimens brought by Mr. Hall may help to supplement the lengthy account of the petrology of Kerguelen Island given by Professors Roth and Renard.

Howe Island. Two rocks—a basalt and a phonolite—were taken from this Island. The basalt is bluish-black in colour, and very fine-grained in texture, olivine is the only mineral which can be detected by the naked eye. Under the microscope the slide appears almost entirely opaque owing to the dissemination of magnetite dust through the matrix. Plagioclase felspar, microliths of felspar, augite and olivine—the last-named often much serpentinized—can be observed.

The occurrence of phonolite on this island does not appear to have been previously noticed. On the weathered surface of the specimen crystals of felspar and augite stand out; the rock breaks with a somewhat even fracture, and felspar and augite are plainly seen embedded in a dark grey matrix of fine-grained texture. The base is micro-granular, composed of grains and

1 J. Roth. Ueber die Gesteine von Kergueland. Monatsber. d.k. preuss. Akad. d. Wiss. Berlin. 1875, pp. 723-735.

2 A. Renard. The Rocks of Kerguelen Island. Narr. Chall. Exp., vol. ii., pp. 107-141.

laths of felspar and augite. In this are set crystals of sanidine, augite, hornblende, and nepheline. The other minerals present are apatite and sphene, with mica and grains of magnetite of secondary origin. The sanidine occurs in tabular crystals, often showing Carlsbad twinning with characteristic broken line of penetration. Augite is present in large crystals with eroded edges and dark zonal border, and also in groups or bunches of small crystals with somewhat ill-defined boundaries. Hornblende has undergone considerable modification by magmatic secretion; the crystal form is as a rule well-preserved, but a dark zonal border has in some cases been formed, leaving an internal portion showing marked pleochroism, while in others the entire crystal has been replaced. Nepheline is present in considerable quantity, it occurs for the most part in microscopic forms giving quadratic and hexagonal sections, but there are a few crystals of large size visible. The other minerals in the slide do not call for any detailed notice.

An analysis of this rock kindly made for me by Messrs. W. H. Green, B.Sc., and B. D. Steele, B.Sc., yielded the following result:—

SiO_2 - - =	53·87	CaO - - =	2·13
TiO_2 - - =	1·10	MgO - - =	0·34
P_2O_5 - - =	0·18	K_2O - - =	6·24
Al_2O_3 - - =	20·64	Na_2O - - =	6·86
Fe_2O_3 - - =	4·51	Loss on ignition =	2·93
FeO - - =	1·42		———
MnO traces			102·22

Twenty-eight per cent. of the rock is soluble in strong HCl.

This analysis completes the determination of the rock as a phonolite; it is in close agreement with that of a phonolite from Greenland Harbour given at page 134 of the Challenger volume.

Greenland Harbour.—The single specimen from this place is an augite-olivine rock approaching in type a limburgite. It has a micro-granular base composed of grains of augite and magnetite, with a small quantity of lath-shaped felspar microliths. No phenocrysts of felspar occur; the olivine crystals are numerous, of large size, and have undergone much serpentinization; there are traces of secondary zeolitic matter.

Royal Sound.—Two specimens come from this place. One is a fine-grained dark coloured rock, breaking with a sub-concoidal fracture. The slices prepared from it show an entirely opaque base, in which crystals of hornblende, augite and apatite can be seen. No traces of felspar can be detected. In many cases the interior of a crystal has been entirely replaced by magnetite, while a bordering zone of translucent material showing weak polarisation tints has been formed round the altered crystal. The other specimen is a small rounded pebble of grey colour and fine-grained texture. There are certain markings on the external surface which simulate the appearance of a fossil, but on examination they are seen to be due to zeolitic matter. Under the microscope the rock is found to be made up of grains of augite pseudomorphic after hornblende, wedged in between lathshaped interlacing felspars twinned according to the Carlsbad law. These felspars present the typical "trachyte" structure; they have a certain linear disposition and show a tendency to flow structure around the phenocrysts of felspar and augite, which they enclose. The character of the felspars points to sanidine, but the amount of alteration which the rock has undergone makes exact determination difficult. I am inclined to class the rock as an augitic trachyte, specimens of which are described from other parts of Kerguelen Island.

"*Cat's Ears.*"—The rocks from this locality are the most important collected by Mr. Hall. Though a description of the hill at the south-west entrance to Royal Sound, known as "Cat's Ears," is given in the Challenger volume, no rocks from the hill were submitted to Professor Renard for examination. Seven specimens—suitable for slicing—were brought back by Mr. Hall, and form an interesting series.

1. A somewhat decomposed vesicular lava in which triclinic felspar, augite, magnetite and altered olivine occur in a glassy base.

2. A decomposed rock in which the minerals which can be determined with certainty are plagioclase felspar—in minute lath-shaped crystals—augite and magnetite. There is a considerable amount of glass present, and in it are numerous colourless acicular crystals of what is probably apatite.

3. A basalt containing much glass, triclinic felspar—showing both albite and pericline twinning—augite and magnetite. The felspar occurs both as phenocrysts and microliths: the augite is present only in grains.

4. A coarse-grained holocrystalline olivine basalt rich in triclinic felspar; augite occurs both as grains and phenocrysts, the latter being sometimes twinned. The slide shows traces of ophitic structure; olivine has been almost entirely serpentinized; magnetite is also present.

5. A volcanic ash with schistose structure. Angular fragments of quartz, plagioclase felspar and augite can be seen, but alteration of the rock renders further determination impossible.

6. A fine grained rock of bluish-black colour, in which felspar and hornblende can be seen. The base is composed of crystals of nepheline, lath-shaped felspars and grains of augite. Sanidine occurs in pellucid crystals of tabular habit and showing Carlsbad twinning. Alteration of the crystal has taken place either by the deposition of opaque specks along the partings, or by infiltration into cracks of silicious matter with high polarisation tints. There is much hornblende, but it has been a good deal modified. Around the larger crystals a deep coloured zonal border has been formed, leaving a strongly pleochroic interior. The smaller crystals have become entirely opaque by the same resorbing action of the magma as that which produced the zonal border in the larger crystals. At the same time, the alteration of the hornblende has been accompanied by the formation of minute irregular grains of augite which surround the hornblende crystals and give them a frayed appearance. Augite also occurs as phenocrysts, but with ill-defined crystal edges. Nepheline is well represented in the slide in microscopic crystals, giving quadratic and hexagonal sections. Apatite occurs in rather long prismatic crystals, and is frequently seen as an inclusion in the hornblende. There is some sphene present and epidote occurs as an alteration product of hornblende. The rock should be classed as a hornblende phonolite.

7. A somewhat decomposed rock of light grey colour, in which felspar and hornblende are visible. There is some glass present in the base, also magnetite, augite grains and microliths of felspar.

The prevailing felspar is sanidine, which occurs in rather large crystals. It is modified just as in the rock No. 6. Hornblende is in considerable quantity, and it has undergone a modification similar to that in the rock just described. Augite is sparingly distributed. Apatite and sphene occur. There are a few altered crystals present which from their sections suggest nepheline; alteration has, however, taken place to such an extent as to make the microscopic determination of this mineral uncertain. In addition to secondary zeolitic matter, there is also some secondary silicious matter filling cracks and cavities in the slide; when visible in cavities it has a radially fibrous structure. The rock may possibly be an altered phonolite.

ART. XVI.—*The Oxidation of Cane Sugar by Aqueous Solutions of Potassium Permanganate.*

(With Plates XXI., XXII.)

BY W. HEBER GREEN, B.Sc.

(Acting-Demonstrator in Chemistry in the University of Melbourne).

[Read 8th December, 1898].

The Dictionnaire de Chemie states that sugar is oxidised entirely to carbonic acid and water by permanganate of potash in an acid solution.

Watt's Dictionary says that sucrose is easily oxidised by all ordinary oxidising agents and that $KMnO_4$ is *said* to yield CO_2 and H_2O; but that Liebig and Pelouze had found that oxalic acid was produced unless an excess of $KMnO_4$ were present, in which case carbonates were formed.

But the accuracy of these statements has been called in question, and at the suggestion of Professor Masson, this research has been undertaken with the view of testing their validity.

It may be observed, however, that the action has not been wholly overlooked, and those chemists who have investigated the subject have found, speaking generally, that the sugar molecule is broken up into molecules of smaller carbon content; oxalates, formates, carbonates and salts of other acids being formed under varying conditions; but considerable differences of opinion prevail as to the manner in which the permanganate is reduced.

Literature of Sugar Oxidation.

Maumené (*Compt. Rend.*, 75, p. 85) gives this equation as the result of his experiments :—

$$10C_{12}H_{22}O_{11} + K_2O \cdot Mn_2O_7 =$$
$$9C_{12}H_{22}O_{15} \cdot K_2O + 2C_6H_{10}O_9 \cdot K_2O + 11Mn_2O_8 + H_2O$$

(potassium hexepate) (potassium trigenate)

He dissolved

200 grammes of sugar-candy in 2 litres of water, and

200 grammes of potassium permanganate in 4 litres of water.

These solutions were then mixed and stirred. The temperature rose 20°C. and the liquid gelatinized. The filtrate was neutral; and on the strength of a few qualitative tests he claimed the discovery of these two new acids.

The latter name, "trigenic," had, however, been applied by Liebig and Wöhler before the year 1850 (*Annalen*, 59, p. 296), to an entirely different compound, $C_4H_7N_3O_2$, which is also known as ethylidene biuret.

In a later paper (*Compt. Rend.*, 120, p. 783) he says that if the precipitated oxide, which is either Mn_2O_3, or a mixture of MnO_2 and MnO, be kept for several days in contact with a strong solution of sugar the brown colour will disappear and hexepic acid ($C_6H_{12}O_8$) be produced. But he explains the failure of other chemists to obtain these acids by the fact that if excess of Mn_2O_3 be present then in time they become further oxidised to form lactic and formic acids.

Heyer (*Arch. Pharm.* [3] 20, p. 430, and *Chem. Soc. abstracts*, 1882, p. 1041) has repeated the experiments of Maumené and other observers. He also employed strong solutions and found that one equivalent of sugar does not react completely in the cold with 4 equivalents of $KMnO_4$, oxalates and formates being obtained; if 12 equivalents of $KMnO_4$ be employed then formates and carbonates, but no oxalates are formed.

$$C_{12}H_{22}O_{11} + 12KMnO_4 = 6KHCO_3 + 6KHCO_2 + 12MnO_2 + 5H_2O.$$

He says that Maumené's "hexepate" was really oxalate, and his "trigenate" was possibly a mixture of acetates and formates of potassium.

Heyer also repeated Langbien's experiments and found that sulphuric acid intensified the reaction; whilst if sufficient acid were present, then a manganese salt, and not one of the oxides, was produced. Also the higher the temperature and the greater the amount of $KMnO_4$ present, the more sugar is completely oxidised to carbonate.

Laubenheimer (*Chem. Soc. abstracts*, 1873, p. 46) obtains a similar result for the oxidation of *Lactose* by warm alkaline solutions of permanganate—CO_2 and MnO_2 being the products.

Smolka (*Monatsh. Chem.* 8, p. 1, and *Chem. Soc. abstracts*, 1887, p. 566) finds that when *Dextrose* is boiled with excess of $KMnO_4$ it is completely oxidised thus:—

$$C_6H_{12}O_6 + 8KMnO_4 = 2KH_3Mn_4O_{10} + 3K_2CO_3 + 3CO_2 + 3H_2O$$

the MnO_2 being in combination with some of the K_2O to form a *potassium hydro-manganite* ($K_2O \cdot 3H_2O \cdot 8MnO_2$).

The amount of oxidation varies with the temperature and concentration of the solution and if there be not excess of $KMnO_4$ present, oxalates, formates and unaltered dextrose, result; whilst the $KMnO_4$ is reduced partly to mangan*ic* and partly to mangan*ous* oxides.

It is obvious that cane sugar would be largely converted into dextrose and laevulose by heating in dilute acid solutions.

Morawski and Stingl (*Journ. der prakt. Chem.* [2] 18, p. 78) find that $KMnO_4$ on reduction in neutral or alkaline solutions with oxalic acid among other reducing agents produces a brown precipitate of $KH_3Mn_4O_{10}$, *i.e.* a salt of tetramanganic acid. They also give a theory of the constitution of $KMnO_4$ and its reduction products.

Feilitzen and Tollens (*Berichte*, 1897, p. 2581) took strong solutions of $KMnO_4$ and sugar containing about 5 equivalents of $KMnO_4$ to one of sugar and left them after mixing until the next day.

The precipitate obtained was thoroughly washed (with alcohol towards the end of the operation), dried, and then analysed with the following result:—

		Percentage Composition.	Chemical Equivalents.
Mn_2O_3	=	83·34	10·32
K_2O	=	9·48	2·0
C	=	0·60	1·0
H_2O	=	8·37	9·2
		100·79	

The amount of carbon was found to vary from 8·5% to 1·6% to 0·6% according to the amount of washing, and was probably due to the presence of some unoxidised sugar.

It will be noted that the precipitate was found to be Mn_2O_3 and not MnO_2.

The K_2O was evidently, partly at all events, in combination with the Mn_2O_3, for it is difficult to understand how so much alkali could have remained merely *adsorbed* after the long continued washing to which it had been subjected.

Preliminary Experiments and Theory of Action.

Test tube experiments shewed that sugar solutions stronger than about ten per cent. readily acted on approximately saturated solutions (6·25 per cent.) of potassium permanganate, either on leaving to stand for a short time or immediately on heating to about 30°C.; in both cases the whole mixture gelatinized, evidently in consequence of the precipitation of a hydrated oxide of manganese. With weaker solutions a higher temperature was required, and the reaction was slower and less energetic, no gelatinization taking place though a precipitate was still formed. The presence of acids such as acetic, hydrochloric and sulphuric, considerably accelerated the action.

With the object of determining the oxidation products of the sugar, I took solutions of about four per cent. strength, and mixed them in the ratio of one molecule of sugar to 4 molecules of $KMnO_4$ approximately. After boiling and filtering from the precipitated oxide, the solution was neutral to litmus, and effervesced with dilute acids, and gave a white precipitate with silver nitrate, soluble in acetic and other dilute acids, and which blackened on heating. No precipitate was obtained with calcium chloride in presence of dilute acetic acid.

These tests indicated the presence of carbonates and formates, and shewed the absence of oxalates.

Possibilities open for the Reaction according to Chemical Theory:

A. Oxidation of the Sugar.

(i.) *Complete Oxidation:*—to *carbonic acid* and water, each sugar molecule requiring 24 atoms of Oxygen. $C_{12}H_{22}O_{11} + 24O = 12CO_2 + 11H_2O$.

(ii.) *Partial Oxidation:*—to *oxalic acid* and water, each sugar molecule requiring 18 atoms of oxygen. $C_{12}H_{22}O_{11} + 18O = 6H_2C_2O_4 + 5H_2O$.

(iii.) *Partial Oxidation:*—to *formic acid*, each sugar molecule requiring 12 atoms of oxygen. $C_{12}H_{22}O_{11} + H_2O + 12O = 12CH_2O_2$.

B. Reduction of the Potassium Permanganate to supply the oxygen necessary for the oxidation of the sugar may also be to one of several conditions.

(i.) *Manganese peroxide*:—MnO_2.

(ii.) *Manganic oxide*:—Mn_2O_3.

(iii.) *Manganous oxide*:—MnO (in form of a manganous salt if in presence of acid).

(iv.) A *variable mixture* of MnO_2, Mn_2O_3 and MnO.

The amounts of oxygen liberated in cases (i.), (ii.) and (iii.), from two molecules of $KMnO_4$ is shewn thus:—

(i.) $2KMnO_4 = 2MnO_2 + K_2O + 3O$.

(ii.) $2KMnO_4 = Mn_2O_3 + K_2O + 4O$.

(iii.) $2KMnO_4 = 2MnO + K_2O + 5O$.

In the case of the sugar being all completely oxidised to carbonic acid, as seems probable, and supposing the $KMnO_4$ to be all reduced to one only of these three conditions, then the number of molecules of $KMnO_4$ required for the oxidation of each sugar molecule will be:—

(1) 16:—if MnO_2 be formed.

(2) 12:—if Mn_2O_3 be formed.

(3) 9·6:—if MnO be formed.

In the possible case of formates or oxalates being produced in the reaction, one half or three quarters of these amounts of $KMnO_4$ would be required.

Preliminary experiments with dilute solutions $\left(\frac{N}{500}\text{ Sugar and }\frac{N}{50}KMnO_4\right)$ shewed that up to 16 equivalents (molecules) of $KMnO_4$, may be decolorised for each equivalent of sugar in presence of dilute sulphuric acid.

In these cases most, if not all of the sugar must have been oxidised to CO_2 and H_2O, and most, if not all of the $KMnO_4$ must have been reduced only to MnO_2.

The action may be tentatively represented as taking place according to this equation if in neutral solution:—

$$C_{12}H_{22}O_{11} + 16KMnO_4 = 8K_2O + 16MnO_2 + 12CO_2 + 11H_2O.$$

We must bear in mind, however, that the K_2O is probably in combination with both the MnO_2 (Smolka, *loc. cit.*, and Morawski

and Stingl, *loc. cit.*) and the CO_2, for the filtrate is neutral to litmus, and effervesces with dilute acids.

If in presence of free acid, this uncertainty does not exist, and as the precipitated MnO_2 is insoluble in dilute sulphuric acid, we may write as the final result of the oxidation of the sugar by acid solutions of permanganate,

$$C_{12}H_{22}O_{11} + 16KMnO_4 + 8H_2SO_4 = 8K_2SO_4 + 16MnO_2 + 12CO_2 + 19H_2O.$$

As, however, we get MnO_2 formed in presence of $KMnO_4$ especially when excess of the latter is used, it is necessary to take account of any possible interaction between them.

Literature of Secondary Reaction.

Morse, Hopkins and Walker (*Am. Chem. Journ.*, 18, p. 401) have shewn that under similar conditions MnO_2 is capable of reducing $KMnO_4$ with liberation of free oxygen. Thenard noticed and commented on this reducing action in 1856.

After pointing out that the stability or otherwise of different samples of "permanganate solutions" is due to the absence or presence of this manganese peroxide, they describe an experiment in which half of the manganese in a measured quantity of $KMnO_4$ is precipitated as MnO_2 by the calculated amount of manganese sulphate and the flask containing the solution immersed in boiling water. After some time the pink colour of $KMnO_4$ will have disappeared altogether. The amount of "active oxygen" remaining, shows that all the manganese is present as MnO_2 and measurement of the oxygen evolved confirms this.

They give this equation as representing the reaction.

$$2HMnO_4 + MnO_2 = H_2O + 3MnO_2 + 3O.$$

The oxide resulting from complete reduction of a neutral solution of $KMnO_4$ contains all the potassium of the original salt and the supernatant liquid is therefore neutral and gives practically no deposit on evaporation.

Unless excess of $KMnO_4$ be present, the precipitated oxide loses oxygen even at ordinary temperatures, so that if it be first dried, or the analysis be delayed for a few hours, then the proportion of oxygen to manganese will be smaller than will satisfy the formula MnO_2.

Possibly this may account for Maumené, Feilitzen and Tollens and others obtaining results indicating that Mn_2O_3 and not MnO_2 is precipitated by sugar from solutions of $KMnO_4$.

Morse and Reese (*Am. Chem. Journ.*, 20, July) contend that the evolution of oxygen observable in most cases where $KMnO_4$ is reduced to MnO_2 is due to this action of the precipitated peroxide on the excess of $KMnO_4$.

Jones (*Journ. Chem. Soc.*, 1878, p. 95), Tivoli (1890) and Gorgen (*Compt. Rend.*, 110, p. 958) have examined the action of various reducing agents on $KMnO_4$, and obtained results confirming this opinion.

Two German Chemists, Meyer and Recklinghausen (*Berichte d. Chem. Ges.*, 29, p. 2828), found that when Hydrogen or Carbon monoxide was absorbed by strong solutions of $KMnO_4$ oxygen was evolved and MnO_2 precipitated; but they argue that this liberation of oxygen was not due to the action of MnO_2 on $KMnO_4$, as the evolution took place mainly, and in some experiments entirely, whilst the Hydrogen on carbon monoxide was being absorbed by the solution.

Further evidence has been produced on both sides, but so far the question can hardly be regarded as settled either one way or the other.

However, it will certainly be necessary to bear this secondary action in mind whilst examining the oxidation of cane sugar.

Experimental Part.

(a) *Objects aimed at.*

The preliminary experiments previously described having approximately shewn that each molecule of sugar requires 16 molecules of $KMnO_4$, at least under certain circumstances, my attention has been directed towards ascertaining under exactly what conditions this complete oxidation of the sugar takes place, and investigating the nature and extent of any secondary reactions or other modifying influences.

To do this it was necessary to determine by series of experiments the effect of varying

(i.) the *ratio* of the sugar, acid and permanganate to one another,

(ii.) the *concentration* of the solutions,
(iii.) the *temperature* of experiment,
(iv.) the *time* of the experiment,

and finally, to decide what was the shortest time in which the reaction could be made to complete itself under suitable and convenient conditions.

(b) *Experimental Methods.*

An attempt was made to titrate a known amount of sugar with a standard solution of $KMnO_4$.

Sugar solutions, even if very dilute, were found in the presence of dilute acids (sulphuric was used) to readily reduce, *i.e.*, decolorize, a few drops of $\frac{N}{50}$ $KMnO_4$ solution, on boiling.

But when about 1·75ccs. $\frac{N}{50}$ $KMnO_4$ had been added in this way to 10ccs. of $\frac{N}{1000}$ Sugar solution in a flask, the brown precipitate which was formed would no longer dissolve, and after nearly 5ccs. of the permanganate solution had been added, its pink colour permanently remained even on continued boiling. Excess of acid did not influence this result.

Nearly 10 equivalents of $KMnO_4$ had been added to each equivalent of sugar, but as 9·6 $KMnO_4$ is required for complete oxidation of sugar, if itself entirely reduced to $MnSO_4$ as apparently was only the case at first, then all the sugar could not have been oxidised to carbonic acid, and probably some was only oxidised to the condition of oxalic or formic acids, or a still lower state of oxidation.

Direct titration not being possible, it was evident that practically only three methods of following the course of the reaction were available.

(i.) Estimation of the carbonic acid, produced by the oxidation of a known weight of sugar, by absorption in soda-lime tubes or otherwise, as in organic analysis.

(ii.) Some modification of the "Forchammer" or "Oxygen" process, which is used for estimating organic matter in potable and other waters.

(iii.) Estimation (volumetrically) of the amount of manganese peroxide precipitated.

The first was not made use of, as the volumetric method, besides being quicker, would give quite as accurate results with the dilute solutions employed.

The method of conducting the experiments was as follows :—

Generally 50ccs. $\frac{N}{50}$ $KMnO_4$ and 5·30ccs. $\frac{N}{500}$ sugar were used, and the desired amount of $\frac{N}{2} H_2SO_4$ added to the same flask. The flask was now heated for the time required at some particular temperature and then rapidly cooled.

The solution could now be filtered through asbestos and the "active oxygen" in either the filtrate or the precipitate or both, estimated by titration with a standard solution of ferrous ammonium sulphate.

In some experiments the solution was not filtered and the total "active oxygen" remaining in the liquid determined in the same way.

The ferrous solution mentioned contained about two equivalents of free sulphuric acid to each equivalent of the salt, in order to render it capable of readily dissolving manganese oxides, and is subsequently denoted by [Fe].

It was soon evident that, to obtain accuracy, attention must be paid to

1 Purity and exact standardization of reagents.
2 Careful regulation of the duration and temperature of experiments.

1. The reagents employed were

(i.) Cane Sugar :—

Ordinary white "brewer's crystals" were used as being almost chemically pure.

At first trouble was experienced with an organic growth in the dilute solutions used; this was effectually prevented by previously rinsing out the well-stoppered bottle with mercuric chloride.

(ii.) Potassium permanganate :—

As the solutions under ordinary circumstances are so unstable, the ordinary pure salt was used, and the solution constantly restandardized with pure iron wire or recrystallized ferrous ammonium sulphate.

(iii.) Ferrous ammonium sulphate :—

The salt obtainable was in obviously impure crystals ; some was recrystallised for use as a standard and found to compare satisfactorily with pure iron wire.

A larger quantity was purified by precipitation with alcohol ; by this means the salt was obtained in a readily soluble powder, which was of about 99 per cent. purity. This was of no consequence, however, for the solution required restandardizing every two or three days.

(iv). A semi-normal sulphuric acid was employed and prepared from the ordinary laboratory reagents.

2. The contents of the flask in which the experiment was conducted were quickly heated by immersing in water a few degrees hotter than the desired temperature and cooled at the conclusion of the experiment in cold water.

In this way an uncertainty of not more than one minute was introduced, and where the experiment continues for an hour or over, this is negligible.

Keeping the temperature constant to within 1°C. is however a more serious consideration.

For temperatures below 100°C. the liquid was contained in ordinary stoppered 100cc. flasks which were allowed to rest on a perforated shelf in a large constant level water-bath. The water was kept at the desired temperature by heating with a bunsen burner.

In my later experiments on the velocity of the reaction efficient circulation of the water was produced by means of a central vertical cylinder surrounding a screw propeller worked by a small water motor.

The temperature was more exactly regulated by a vapour pressure thermostat and the effect of air currents minimised by the use of separate covers fitting over the neck of each flask.

The circulation of the water takes place in a uniform manner, the current passing up through the central cylinder from directly over the flame, and it then spreads out across the shelf and around the flasks and thermostat, and finally down the sides through openings for that purpose.

The result is that a thermometer with the bulb placed in any part of the vessel shews readings not differing by more than 1°C., and if kept in the region of the flasks, this difference practically vanishes.

Where 100°C. was the temperature desired, the flask was simply placed on a sand bath, so heated that the liquid was just kept in a state of quiet ebullition.

(c) *Calculation of Results.*

In the titration of the amount of reduction undergone by the $KMnO_4$ in any experiment, one or more of three methods was employed.

1. Estimation of the amount of *MnO_2 precipitated* by complete filtration of the solution through asbestos, and washing of the precipitate until no pink colour of $KMnO_4$ remained.

This precipitate was then *at once* dissolved in excess of $\frac{N}{10}$ or $\frac{N}{50}$ [Fe] and then the excess determined by titration with $\frac{N}{50}KMnO_4$.

2. Estimation of the *$KMnO_4$ reduced* to MnO_2; this was done in either of two ways.

(i.) The liquid and precipitate was made up to 100ccs., and then *part* of it filtered into a burette and titrated against a fixed volume of [Fe].

A simple calculation gives the amount of $KMnO_4$ reduced to MnO_2, and this method was employed in the majority of my earlier experiments.

Thus in experiment 2 of Table II., it was found that 14·4ccs. of the filtered solution were

required to produce a pink coloration in 5ccs. $\frac{N}{10}$ [Fe].

but as 5ccs. $\frac{N}{10}$ [Fe] is equivalent to (will combine with) 1cc. $\frac{N}{10} KMnO_4$.

14·4ccs. of the filtered solution contained as much $KMnO_4$ as 10ccs. $\frac{N}{100} KMnO_4$.

$$\therefore \ 100\text{ccs. contained } \frac{1000}{14 \cdot 4}\text{ccs., } \frac{N}{100} KMnO_4$$
$$= 69 \cdot 44\text{ccs. } \frac{N}{100} KMnO_4.$$

and 100 − 69·44 (*i.e.*, 30·56) $\frac{1}{100}$-milligram molecules of $KMnO_4$ have been reduced to MnO_2.

(ii.) By complete filtration of all solution and separation of all MnO_2.

The filtrate and washings were then made up to 100ccs. and their value estimated as in (2) (i.), or the whole may be neutralised with excess of ferrous solution as in (1).

The precipitated MnO_2 can also be estimated by (1). The objection to (i.) is that the volume of the precipitated MnO_2 is not allowed for, and adsorbtion may also exercise an effect on the result. Probably both sources of error are negligible, especially as they tend to neutralize one another.

The disadvantage of (ii.) is that it involves the complete filtration of the whole of the solution and thorough washing of the precipitate; operations which occasionally (when the asbestos filter becomes clogged) may be very tedious.

3. Estimation of the *total loss* of "*active oxygen*" in the liquid.

(i.) This may be calculated from 1 and 2 (ii. combined). The concordance of the results so obtained is a useful check on the accuracy of the work.

(ii.) It may also be determined directly by adding excess of ferrous solution directly to the liquid and then titrating back with standard $KMnO_4$ in the usual way.

This method is superior to the others, both in point of accuracy and of speed when only a small amount of MnO_2 has been precipitated, for then 50ccs. of $\frac{N}{10}$ [Fe.] (equivalent to the 50ccs. of $\frac{N}{50}KMnO_4$ originally present) can be directly added, the same pipette being used for the measurement of both solutions, and the excess of ferrous salt readily determined by titration with $\frac{N}{50}KMnO_4$.

(d) *Explanation of tables of results.*

The columns indicating the time and temperature of experiments and the amounts of $\frac{N}{50}KNnO_4$, $\frac{N}{500}$ sugar and the amounts $\frac{N}{2}H_2SO_4$ do not need further elucidation.

The results of the titrations have been given in one of three columns according to the method of estimation.

α. The amount of *$KMnO_4$ reduced to MnO_2* expressed in $\frac{1}{100}$ milligram molecules. It will be noted that originally 1 milligram molecule of $KMnO_4$ was present.

β. The amount of *MnO_2 precipitated*, expressed in $\frac{1}{100}$ milligram molecules.

γ. The *loss of "active oxygen"* in $\frac{1}{100}$ milligram atoms. Originally 2·5 milligram atoms of active oxygen were present.

Another column has been added, giving the number of *oxygen atoms abstracted* from the solution *per molecule of sugar* employed.

According to the equation each molecule of sugar should require twenty-four atoms of oxygen for its complete oxidation to CO_2.

RESULTS OF EXPERIMENTS.

Comparatively strong solutions containing $\frac{N}{2 \cdot 5} KMnO_4$ and $\frac{N}{10}$ sugar with large excess of H_2SO_4 (100 molecules of $KMnO_4$ being present to 1, 2, 4 and 6 molecules of sugar in different experiments) were left stand over night.

The results obtained were complicated and in every case far too much $KMnO_4$ was reduced. This was evidently the result of some secondary action, probably the reduction of $KMnO_4$ by the MnO_2.

Consequently I decided to restrict myself to the use of dilute solutions, viz., $\frac{N}{50} KMnO_4$ (containing 3·1638 grams per litre) and $\frac{N}{500}$ sugar (containing ·6843 grams per litre).

(i.) *Experiments at ordinary temperature* (21°C.).

Solutions were made up as indicated in table on Friday afternoon and allowed to stand until the following Monday morning, *i.e.*, 64-68 hours. The solutions were then diluted to 100ccs. and sufficient filtered into a burette to titrate against either 10 or 20ccs. $\frac{N}{50}$ [Fe.]

The results shew that the reaction is not complete after three days' contact at this temperature.

TABLE I.

Time of experiment, 64–68hrs. Temperature 21°C.

50ccs. $\frac{N}{50} KMnO_4$ and 5ccs. $\frac{N}{2} H_2SO_4$ were employed in each experiment.

No. of Experiment.	Sugar Employed.	Ferrous Solution used.	Result of titration.	$KMnO_4$ reduced to MnO_2 (a)	Oxygen atoms abstracted per molecule of Sugar.
1	5ccs. $\frac{N}{500}$	20ccs. $\frac{N}{50}$	9·3ccs.	13·8	20·7
2	10 „	„	11·3 „	29·2	21·9
3	15 „	„	14·2 „	43·65	21·8
4	25 „	10ccs. $\frac{N}{50}$	13·5 „	71·35	21·4

(ii.) *Experiments at* 50°–60°C.

A solution was made up containing 15 molecules of $KMnO_4$ to 1 of sugar, and placed in a flask immersed in water heated to 50°–60°. All the $KMnO_4$ has not been reduced to MnO_2 at the end of 2½ hours.

The temperature was then raised to 80° and the remaining colour disappeared in less than 20 minutes.

As the action was so slow at 50°–60°, further experiments were not attempted at this temperature.

(iii.) *Experiments at temperatures above* 80°C.

From 80° to 90° has appeared to be the most convenient temperature, for if colder the action is too slow, and if hotter, then the secondary action has an appreciable influence on the result.

It will be seen from the table of results, that the reaction at this temperature is practically complete in 1 hour under these conditions of experiment. Experiment 4 is apparently incorrect. The high values in Experiments 9, 10 and 11 are apparently due to the secondary action being accelerated by the higher temperature. The action is evidently not largely affected by the quantity of acid present, when within moderate limits; see Experiments 2, 3 and 7.

TABLE II.

50ccs. $\frac{N}{50}KMnO_4$ was employed in every case.

The amount of sugar was arranged so that the ratio of sugar molecules to $KMnO_4$ molecules originally present varied from 1%–5%.

No. of Experiment.	Time in Hours.	Temperature of Experiment.	ccs. of $\frac{N}{2}$ Acid used.	ccs. of $\frac{N}{500}$ Sugar used.	Per cent.	$KMnO_4$ reduced to MnO_2 (*a*)	Oxygen atoms abstracted per molecule of Sugar.
1	1¼	80°	10ccs.	10ccs.	2	30·56	22·92
2	1	80°–90°	0·75	20	4	64·6	24·23
3	1	,,	2·0	20	4	64·52	24·2
4	1	,,	5·0	10	2	28·66	21·5
5	1	,,	,,	15	3	48·4	24·2
6	1½	,,	,,	15	3	48·06	24·03
7	1	,,	,,	20	4	62·12	23·24
8	1	,,	,,	25	5	79·65	23·90
9	2	80°–95°	,,	5	1	17·23	25·84
10	2	,,	,,	10	2	34·96	26·22
11	1½	,,	,,	10	2	32·84	24·63

It was thought advisable to determine the influence, if any, of both much larger and smaller quantities of acid, as the action may possibly be considerably influenced thereby.

The results obtained shewed that when no acid was present, comparatively little action takes place, but as long as sufficient acid is present to combine with the potassium of the reduced $KMnO_4$, only a slight effect is produced by even increasing the acid sixty-fold. (See Experiments 2, 3 and 4 in Table III.).

TABLE III.

50ccs. $\frac{N}{50}$ $KMnO_4$ and 15ccs. $\frac{N}{500}$ sugar were employed in every case.

No. of Experiment.	Time in Hours.	Temperature of Experiment.	ccs. of $\frac{N}{2}$ acid employed.	$KMnO_4$ reduced to MnO_2 (a)	Oxygen atoms abstracted per molecule of Sugar.
1	1	(82°) 79°·5–84°·5	none	19·6	9·8
2	1	(80°) 75°–85°	0·5 ccs.	45·4	22·7
3	1	(82°) 79·5–84·5	1·0 ccs.	46·4	23·2
4	1	(80°) 75–85	30 ccs.	47·4	23·7
5	1¼	(85) 84–86	·5 ccs.	46·8	23·4
6	1¼	(83) 84–86	30 ccs.	48·4	24·2

The effect of a still higher temperature remained to be investigated, and with this object experiments were undertaken at the boiling point (101°C.).

Table IV. clearly shows that while 24 atoms of oxygen to each molecule of sugar had been abstracted from the solution in the first 30 minutes, yet the secondary action had attained to such importance that no less than 14% of the remaining $KMnO_4$ was reduced to MnO_2 in the following 30 minutes.

Sufficient sulphuric acid was present to combine with the potassium of all the $KMnO_4$ employed.

TABLE IV.

50ccs. $\frac{N}{50}$ $KMnO_4$, 15ccs. $\frac{N}{500}$ sugar and 1cc. $\frac{N}{2}$ H_2SO_4 were employed in each experiment.

No. of Experiment.	Time in Minutes.	Temperature of Experiment.	$KMnO_4$ reduced to MnO_2 (a)	Oxygen atoms abstracted per molecule of Sugar.
1	15	101°C	46·05	23·02
2	30	,,	48·16	24·08
3	45	,,	50·25	25·12
4	60	,,	55·0	27·5

The question arises as to whether the reduction of the $KMnO_4$ will continue even after all the sugar can reasonably be assumed to have been oxidised. According to Morse and Reese (*loc. cit.*) the action should not stop until all the $KMnO_4$ has been decolorized, and even then the MnO_2 itself should begin to lose oxygen.

My experiments (Table V.) bear out this view as far as they go.

In Experiment 1 no organic reducing agent was present.

TABLE V.

50ccs. $\frac{N}{50}$ $KMnO_4$ were employed in each experiment.

No. of Expt.	Time in Hours.	Temperature of Experiment.	ccs. of $\frac{N}{500}$ Sugar used.	Per cent.	ccs. of $\frac{N}{2}$ H_2SO_4	$KMnO_4$ reduced to MnO_2 (a)	Loss of "Active Oxygen" (γ)	Oxygen atoms abstracted per molecule of Sugar.
1	4¼	(94°) 92°–96°	none		25 ccs.		22·4	
2	3½	(95°) 93°–98°	15	3	·66	51·9		26·0
3	3½	(95°) 93°–98°	15	3	30 ccs.	57·9		29·0
4	4¼	(94°) 92°–95°	10	2	·66	35·0		26·2
5	4¼	(94°) 92°–95°	10	2	30 ccs.	43·1		32·3
6	4	(94°) 92°–96°	10	2	30 ccs.	45·3		34·0

As in all these series of experiments, the presence of the acid exercises a notable effect, it was thought advisable to determine the amount of reduction undergone by an ordinary standard solution of $KMnO_4$ when heated with varying amounts of dilute H_2SO_4 at different temperatures.

The amount of reduction was estimated by titration against [Fe.] Solution.

TABLE VI.

No sugar was employed in these experiments.

No. of Experiment.	Temperature of Experiment.	Time in Hours.	$\frac{N}{50}KMnO_4$ employed.	$\frac{N}{2}H_2SO_4$ present.	Percentage loss of "active oxygen" of $KMnO_4$ solution.
1	101°C.	1	50ccs	5ccs.	1·25%
2	,,	1	25ccs.	15ccs.	2·25%
3	94°C.	1	50ccs.	10ccs.	·4 %
4	,,	2	,,	10ccs.	1·65%
5	,,	1	,,	20ccs.	·4 %
6	,,	4¼	,,	25ccs.	9·0 %
7	,,	1	,,	30ccs.	1·0 %
8	80°C.	4	25ccs.	0ccs.	·37%
9	,,	4	,,	5ccs.	1·9 %
10	,,	4	,,	25ccs.	2·1 %

It seemed possible that a method based on this reaction might be worked out for the estimation of cane sugar in dilute solutions somewhat on the lines of the Forchammer process, which is used for the detection and estimation of organic matter in potable and other waters.

It will of course be necessary to make a correction for the secondary action or to render it inappreciable.

Several series of experiments have been carefully performed with the object of measuring the velocity of the reaction at different temperatures: these will indicate (*a*) the time required for the theoretical amount of $KMnO_4$ to be reduced, (*b*) the effect due to the secondary action on continuing the experiment beyond that time.

It should be possible from the laws of mass action to calculate the amount of $KMnO_4$ reduced in any given time.

Table VII.

Velocity of the reaction at 101°C.

50ccs. $\frac{N}{50}$ $KMnO_4$, 15ccs. $\frac{N}{500}$ sugar and 1cc. $\frac{N}{2}$ H_2SO_4 were used in every case, except Experiment 8.

No. of Experiment.	Time in Minutes.	$KMnO_4$ reduced to MnO_2 (α)	Amount of MnO_2 precipitated. (β)	Oxygen atoms abstracted per molecule of Sugar (average value)
1	5	38·8	40·4	19·8
2	10	45·6	45·95	22·9
3	15	46·8	47·2	23·5
4	20	47·9	48·1	24·0
5	30	49·7		25·1
6		50·3	50·7	
7	40	51·3	51·4	25·65
8*	20	49·3	49·2	24·65

* In Experiment 8, 5ccs. $\frac{N}{2}$ H_2SO_4 were employed. (Compare with Experiment 4).

Table VIII.

Velocity of the reaction at 94°C.

50ccs. $\frac{N}{50}$ $KMnO_4$, 15ccs. $\frac{N}{500}$ sugar and 1cc. $\frac{N}{2}$ H_2SO_4 were used in every case.

No. of Experiment.	Time in Minutes.	$KMnN_4$ reduced to MnO_2 (α)	MnO_2 precipitated. (β)	Loss of "active oxygen." (γ)	Oxygen atoms abstracted per molecule of Sugar (average value).
1	10			55·75	18·58
2	20	45·18	45·3		22·62
3	30	47·25	47·25		23·62
4	35	48·09			24·05
5				71·4	23·80
6	40	48·81	48·80		24·4
7*	45	48·81	49·0		24·45
8	60	49·87	49·8		24·93
9	80			75·4	25·13
10	90	50·67			25·33

* The temperature of Experiment 7 was about 0·5°C. lower than Experiment 6, hence the closeness of the results.

TABLE IX.

Velocity of the reaction at 84·5°C.

50ccs. $\frac{N}{50}KMnO_4$, 15ccs. $\frac{N}{500}$ sugar and 1cc. $\frac{N}{2}H_2SO_4$ were used in every case.

No. of Experiment.	Time in Minutes.	$KMnO_4$ reduced to MnO_2 (α)	MnO_2 precipitated. (β)	Loss of "active oxygen." (γ)	Oxygen atoms abstracted per molecule of Sugar (average).
1	10			35·75	11·92
2	20			60·75	20·25
3	40	44·44	43·15		22·83
4	40			69·60	23·2
5	60	47·58	47·5		23·83
6	80			73·65	24·55
7	80	48·85	48·75		24·47
8*	120	49·95	48·9		25·32

* The temperature of Experiment 8 was 85°C.

It will be seen that at 101°C. the action reaches its theoretical limit in 20 minutes, but the secondary action is so appreciable that an error of 1 per cent. would be produced by allowing the action to continue for one minute longer. At 94°C., about 35 minutes are required, and at 84·5°C., about 65 minutes, but in these cases an error of two or three minutes is insignificant.

It was now necessary to vary the amount of sugar present, for in these three series of experiments, 15ccs. of $\frac{N}{500}$ sugar solution had been employed in each case.

The following experiments show that under the conditions of experiment the amount of action is considerably influenced by the volume of the solution, and in this particular case the number of oxygen atoms "abstracted" per molecule of sugar varies inversely as the square root of the volume, approximately. This is evidently an empirical relation only.

TABLE X.

Influence of varying the sugar present.

50ccs. $\frac{N}{50}$ $KMnO_4$ and 1cc. $\frac{N}{2}$ H_2SO_4 were employed in each case.

Duration of Experiment, 30 minutes. Temperature, 94°C.

No. of Experiment.	ccs. of $\frac{N}{500}$ Sugar used.	Total volume of Liquid.	$KMnO_4$ reduced to MnO_2 (α)	MnO_2 precipitated. (β)	Loss of "active oxygen."	Oxygen atoms abstracted per molecule of Sugar (average).
1	5	56ccs.	16·7	17·0		25·27
2*	15	66ccs.	47·25	47·25		23·62
3	25	76ccs.			111·25	22·25

* This experiment has been given before in Table VIII.

It was evident that the volume must be kept constant, so another series of experiments was conducted at 85·0°C., in which, after adding the $KMnO_4$, acid and sugar and sufficient distilled water was run in to make the total volume up to 76ccs.

As diluting the solution will naturally make the action slower, the duration of each experiment was fixed at 80 minutes.

TABLE XI.

Influence of varying the amount of sugar present.

50ccs. $\frac{N}{50}$ $KMnO_4$ and 1cc. $\frac{N}{2}$ H_2SO_4 were employed in every case.

Duration of Experiment, 80 minutes. Temperature, 85°C.

No. of Experiment.	ccs. of $\frac{N}{500}$ Sugar present.	Per cent.	Total loss of "active oxygen." (γ)	Excess over the theoretical limit.	Oxygen atoms abstracted per molecule of Sugar.
1	none		0·25	0·25	—
2	0·5ccs.	0·1	3·6	1·2	35·0
3			24·6	·6	
4	5	1	24·6	·6	24·7
5			24·95	·95	
6	10	2	49·2	1·2	24·6
7	15	3	72·25	·25	24·08
8	20	4	93·5	–2·5	23·4
9	25	5	111·65	–8·35	22·33

It will be seen that the reduction in Experiment 1 was only equivalent to 1 part in 1000, an amount only just recognizable by volumetric methods, whilst in Experiment 2, a comparatively large reduction has been effected by the formation of an appreciable, though small, amount of MnO_2.

The accompanying plate shews that the curve, representing the amount of action, at first runs just above and parallel to the theoretical line until after passing the 3% mark, when it crosses the line and suddenly bends downwards.

The amount of sugar contained in 25ccs. of an aqueous solution may be easily estimated in this way, provided that between 1% and 3% of a milligram-molecule is present, a small correction being made for the secondary action.

But outside these limits the process, in its present form, is not susceptible of much accuracy.

Three methods of overcoming the difficulty have presented themselves (*a*) by increasing the duration of each experiment to, say, two hours. This was tried, but the results obtained were unsatisfactory. (*b*) it was suggested that perhaps the sucrose would not itself reduce the $KMnO_4$, but would only do so after inversion, as in the case of "Fehlings" solution, and that consequently, if this were so, previous inversion of the sugar solution should considerably increase the velocity of the reaction. This was also tested by experiment, but without any notable result. (*c*) by increasing the amount of acid to 5ccs. or 10ccs. of $\frac{N}{2}$ H_2SO_4 and if not too tedious, working at a lower temperature in order to minimise the secondary action.

It is my intention to pursue this method further, as there is room for a process capable of more than approximately estimating the sucrose in such dilute solutions (0·3 per cent.) as we are here concerned with.

As previously intimated, it should be possible to deduce a formula which will fit the curves that have been obtained at 101°, 94° and 85°C.; of course a correction must be made for the influence of the secondary action and this, though small, is difficult to exactly determine.

I have attempted to apply the equations for mono-, di- and tri-molecular changes to the results obtained at 84°·5C.; as was to be expected they did not agree, the curve being evidently of a much higher degree and requiring a considerably more complicated equation.

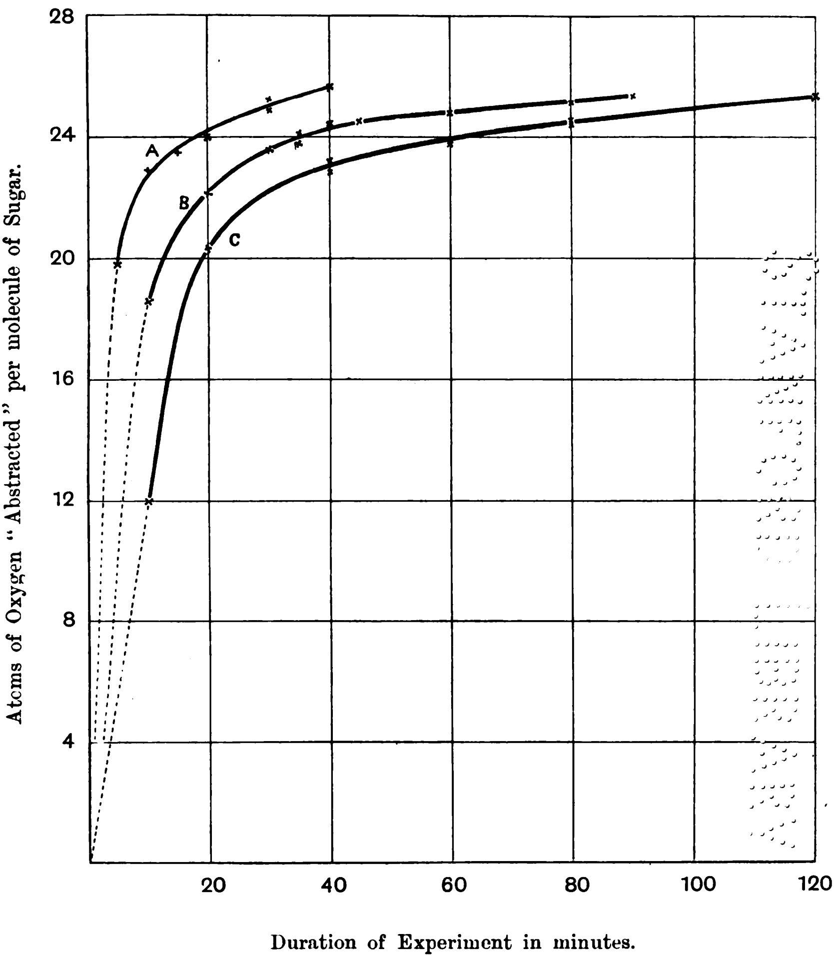
The results obtained so far may, I think, be summarized as under:—

1. Cane sugar is completely oxidised to carbon dioxide and water by potassium permanganate in dilute and acid solutions containing excess of the permanganate.
2. The potassium permanganate is reduced, under these conditions, to a hydrated manganese peroxide.
3. A *secondary action* which proceeds simultaneously is caused by this precipitated oxide acting "catalytically," and reducing more of the $KMnO_4$ to MnO_2 with liberation of oxygen gas.
4. These reactions may be represented by the following equations:—

   (i.) $C_{12}H_{22}O_{11} + 16KMnO_4 + 8H_2SO_4 = 8K_2SO_4 + 16MnO_2 + 12CO_2 + 11H_2O$

   (ii.) $4KMnO_4 + xMnO_2 + 2H_2SO_4 = 2K_2SO_4 + (x+4)MnO_2 + 2H_2O + 3O_2$
5. The primary action indicates a method for the estimation of cane sugar in dilute aqueous solutions, bearing in mind the restrictions discussed on p. 235.
6. The velocity of both reactions increases notably, but not in a simple manner, with the concentration, acidity and temperature of the solution.
7. When excess of potassium permanganate is *not* employed, then lower oxidation products of sugar, such as formates and possibly oxalates and glycollates, are formed, as well as carbon dioxide.

These experiments have been carried out in the Chemical Laboratory of the University of Melbourne, and I desire greatfully to acknowledge my deep obligations to Professor Orme Masson for valuable encouragement and advice afforded me in connection with this work.


28
24
20
16
12
8
4
A
B
C
20
40
60
80
100
120
Atoms of Oxygen "Abstracted" per molecule of Sugar.
Duration of Experiment in minutes.

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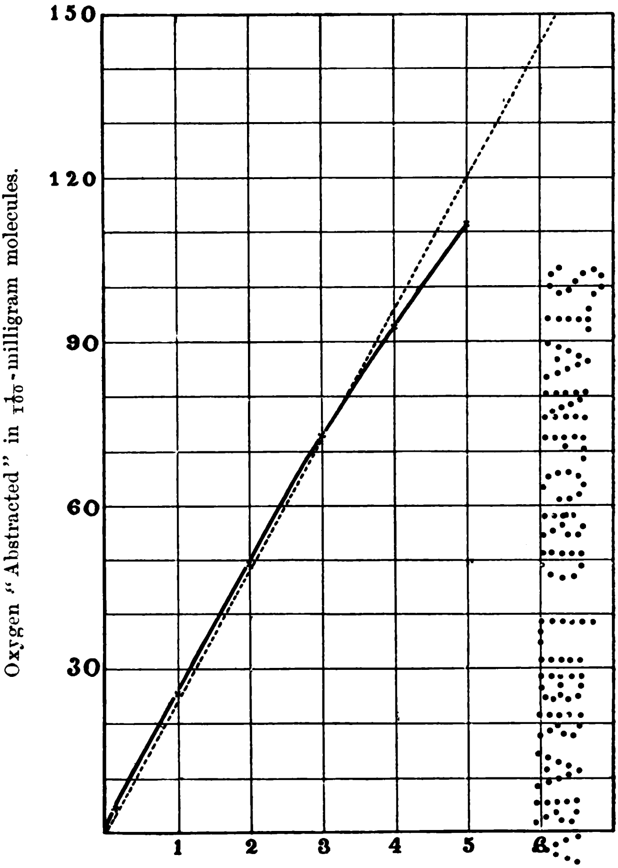

Molecules of Sugar employed per 100 molecules of $KMnO_4$.

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EXPLANATION OF PLATES XXI. AND XXII.

Plate XXI.

Curves shewing the number of *Oxygen Atoms* "abstracted" from a potassium permanganate solution *per* molecule of sugar present, on heating for different times.

A. at 101°C. (*Vide* Table VII.).
B. at 94°C. (*Vide* Table VIII.).
C. at 84°·5C. (*Vide* Table IX.).

Plate XXII.

Curve shewing the influence of varying amounts of sugar on the reduction of potassium permanganate solution; the action being continued for eighty minutes at 85°C. (*Vide* Table XI.).

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR 1897.

The Council of the Royal Society herewith presents to the Members of the Society the Annual Report and Balance Sheet for the Year 1897.

The following Meetings were held, and Papers read during the Session :—

March 11.—1. "The Burbung of the Darkinung Tribes," by R. H. Mathews (communicated by Professor Baldwin Spencer, M.A.) 2. "Contributions to the Palæontology of the Upper Silurian Rocks of Victoria, based on specimens in the collection of Mr. George Sweet" (Part I.), by W. S. Dun.

April 8.—1. "Three months' Prehistoric-Man Hunting in Africa," by H. W. Seton-Karr (communicated by the Hon. Secretary). 2. "An Account of the Engwurra or Fire Ceremony of certain Central Australian Tribes," by Professor Baldwin Spencer, M.A., and F. J. Gillen (illustrated by limelight views from photographs taken by the authors).

May 13.—1. "On the Occurrence of the Lower Silurian (Ordovician) Graptolites at Matlock, and a note on *Dictyonema magillivrayi* (nom. mut.)," by T. S. Hall, M.A. 2. "A Note on Wave Action in Bass Strait," by T. W. Fowler, M.C.E. 3. "A Note on the Construction of Sextants," by T. W. Fowler, M.C.E. 4. "The Wandarral of the Richmond and Clarence River Tribes," by R. H. Mathews.

June 10.—1. "The Geology of the Lower Moorabool," by T. S. Hall, M.A., and G. B. Pritchard. 2. "The Geology of Coimaidai," Part I.: "The Coimaidai Limestone and Associated Deposits," by G. Officer, B.Sc., and E. G. Hogg, M.A. 3. "Note on a Tooth of Palorchestes from Beaumaris," by T. S. Hall, M.A., and G. B. Pritchard. 4. "The Spectra of the Alkalies and their Atomic Weights," by L. Rummel.

July 8.—1. "Recent Work on Graptolites," by T. S. Hall, M.A. 2. "An Entropy Metre," by E. F. J. Love, M.A.

August 12.—1. "On a Method of Determining the Specific Heat of Liquids, especially of Solutions," by Walter Rosenhain. 2. "Description of a New Species of Unio from the River Glenelg," by J. Dennant, F.G.S. 3. "Exhibition of an Opacity Photometer," by R. L. J. Ellery, F.R.S.

September 9.—"Electric Telegraph without Wires by means of Hertz Waves," by G. W. Selby, (illustrated by experiments).

October 21.—1. "Observations on *Muridae* from Central Australia," by Edgar R. Waite, F.L.S. 2. "The Miocene Strata of the Gippsland Lake Area," by J. Dennant, F.G.S., and D. Clark, B.C.E. 3. "Catalogue of Marine Shells of Victoria," Part I., by J. H. Gatliff and G. B. Pritchard. 4. "Perforated Rocks in Western Australia," by E. J. Dunn, F.G.S.

November 11.—1. "The Geology of Coimaidai," Part II., by Graham Officer, B.Sc., and Evelyn G. Hogg, M.A. 2. "Stylasteridæ from Victorian Tertiaries," by T. S. Hall, M.A. 3. "Notes on certain Initiation Ceremonies of the Natives of Central Australia," by Baldwin Spencer, M.A., and F. J. Gillen, Sub-Protector of Aborigines, Alice Springs.

December 9.—1. "On the Structure of the Australian Land Leech," by Ada M. Lambert, M.Sc. (communicated by Professor Spencer). 2. "The Northward Extension of the Derrinal Glacial Conglomerate," by E. J. Dunn, F.G.S. 3. "Note on an Additional Genus of Fossil Plants found in the Bacchus Marsh Sandstone by Mr. Geo. Sweet, F.G.S.," by Sir Frederick McCoy, K.C.M.G., M.A., D.Sc., F.R.S., etc. 4. "Exhibit of Professor Sylvanus Thompson's form of Osborne Reynold's Wave Apparatus," by G. W. Selby. 5. "Exhibit of Fossil Bones from the Buninyong Estate Mine and Fossil Insect Remains from the Stony Creek Basin, near Daylesford," by T. S. Hart, M.A.

During the course of the year the Society has lost by resignation two ordinary and one country member and three associates, while it has gained six ordinary and four country members and two associates.

It has been decided for the present to suspend the rule referring to the payment of entrance fee to the Society. Your

Council has to report with regret that there are a considerable number of members who are in arrears in regard to the payment of subscriptions. With the cutting down of the Government Grant, which is now only £100 per annum, and at the same time a steady influx of work requiring publication, it has become a matter of increasing difficulty how to provide for the latter.

Owing to the kindness of the Council of the Working Men's College half of the spare copies of former publications of the Society are now stored in the strong room of the College, thus minimising the risk of losing the series in case of fire.

Your Council has to acknowledge with thanks, the gift of £68, which was anonymously presented by one of its members.

During the year the following publication has been issued, viz., "Proceedings," Vol. X., Part I., (New Series); at the present moment Vol. X., Part II., is in the press, and will shortly be ready for distribution. It has been decided in future to publish two parts of the "Proceedings" during each year.

The Librarian reports that 1164 publications have been received during the year. The Periodicals have been catalogued, and a card catalogue has been prepared, which will be available for members when the list of books has been completed. The sum of ten pounds has been voted by the Council for binding, none of which has as yet been expended.

The Honorary Treasurer in Account with the Royal Society of Victoria.

Dr.			Cr.	
To Balance from 28th February, 1897 ...		£16 11 0	By Printing and Stationery	£147 19 6
Government Grant—			Rates	3 10 0
Balance of Vote, 1895-96	£50 0 0		Gas and Fuel	6 15 6
Instalment for 1896-97	50 0 0		Salary of Assistant-Secretary ...	80 13 1
		100 0 0	Custodian	6 0 0
Entrance Fees		4 4 0	Collector's Commission	17 6 5
Subscriptions—			Insurance	8 8 3
Members ...	£64 1 0		Postages	28 12 0
Country Members	10 12 0		Repairs	5 13 9
Associates ...	30 19 6		Books and Periodicals	3 2 6
Arrears	54 1 6		Freight	2 17 0
		159 14 0	Refreshments	1 9 8
Rent of Rooms		8 12 6	Advertising	3 0 0
Sale of "Proceedings"		4 19 6	Binding	1 9 0
Donation from Member		68 5 0	Incidentals	5 10 6
Transferred from Research Fund ...		100 0 0	Exchange	0 6 0
Interest		6 0 0	Balance (28th February, 1898) ..	145 12 10
		£468 6 0		£468 6 0

PUBLISHING AND RESEARCH FUND.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Fixed Deposit in Bank	£300	0	0	By Transfer to General Account	£100	0	0
Interest on same	6	0	0	Interest transferred to General Account	6	0	0
				Balance of Fixed Deposit in Bank of Australasia	200	0	0
	£306	0	0		£306	0	0

Compared with the Vouchers, Bank Pass-Book and Cash-Book, and found correct,

H. MOORS,
JAMES E. GILBERT, } *Auditors.*

C. R. BLACKETT,
Hon. Treasurer.

28th February, 1898.

The Honorary Treasurer in Account with the Royal Society of Victoria.

Dr.

	£	s.	d.	£	s.	d.
To Balance from 28th February, 1897 ...				£16	11	0
Government Grant—						
Balance of Vote, 1895-96	£50	0	0			
Instalment for 1896-97	50	0	0			
				100	0	0
Entrance Fees				4	4	0
Subscriptions—						
Members ...	£64	1	0			
Country Members	10	12	0			
Associates ...	30	19	6			
Arrears	54	1	6			
				159	14	0
Rent of Rooms				8	12	6
Sale of "Proceedings"				4	19	6
Donation from Member				68	5	0
Transferred from Research Fund ...				100	0	0
Interest				6	0	0
				£468	6	0

Cr.

	£	s.	d.
By Printing and Stationery	£147	19	6
Rates	3	10	0
Gas and Fuel	6	15	6
Salary of Assistant-Secretary ...	80	13	1
Custodian	6	0	0
Collector's Commission	17	6	5
Insurance	8	8	3
Postages	28	12	0
Repairs	5	13	9
Books and Periodicals	3	2	6
Freight	2	17	0
Refreshments	1	9	8
Advertising	3	0	0
Binding	1	9	0
Incidentals	5	10	6
Exchange	0	6	0
Balance (28th February, 1898) ...	145	12	10
	£468	6	0

PUBLISHING AND RESEARCH FUND.

Dr.		Cr.	
To Fixed Deposit in Bank	£300 0 0	By Transfer to General Account	£100 0 0
Interest on same	6 0 0	Interest transferred to General Account	6 0 0
		Balance of Fixed Deposit in Bank of Australasia	200 0 0
	£306 0 0		£306 0 0

Compared with the Vouchers, Bank Pass-Book and Cash-Book, and found correct,

H. MOORS,
JAMES E. GILBERT, } *Auditors.*

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28th February, 1898.

The Royal Society of Victoria.

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WITH THEIR YEAR OF JOINING.

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Forrest, The Hon. Sir J., K.C.M.G., West Australia ... 1888

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Neumayer, Professor George, Ph.D., Hamburg, Germany 1857

Russell, H. C., B.A., F.R.S., F.R.A.S., Observatory, Sydney, N.S.W. 1888

Scott, Rev. W., M.A., Kurrajong Heights, N.S.W. ... 1855

Selwyn, Dr., A. R. C., 1374 Broughton-street, Vancouver, B.C. 1897

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Eaton, H. F., "Yatala," Walsh-street, South Yarra ... 1857
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Gilbert, J. E., 210 Walsh-street, South Yarra 1872

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Candler, Samuel Curtis, Melbourne Club, Melbourne ... 1888

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Dunn, E. J., F.G.S., "Taiynan," Mary-street, Grace Park, Hawthorn 1893

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Hogg, E. G., M.A., Trinity College, University, Melbourne 1894
Howitt, A. W., F.G.S., Finch-street, South Malvern ... 1877

James, E. M., M.R.C.S., c/o The Hon. Sir William Zeal, 5 St. James' Buildings, William-street 1883
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Walcott, H. R., F.G.S., Technological Museum, Swanston-street 1897
Wilkinson, W. Percy, F.C.S., College of Pharmacy, Melbourne 1894
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McDougall, Duncan, Maryborough, Victoria 1897

Oddie, James, Dana-street, Ballarat, Victoria 1882
Officer, Sidney, Maryvale, Boroke 1890

Powell, Walter D. T., Cape Moreton Light House, Brisbane, Queensland 1886
Purdie, A., M.A., School of Mines, Adelaide, S.A. ... 1892

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Stirton, James, M.D., F.L.S., 15 Newton-street, Glasgow 1880

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Avery, D., M.Sc., Working Men's College, Melbourne ... 1893

Baker, Thomas, Bond-street, Abbotsford, Victoria ... 1889
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Campbell, A. J., Elm Grove, Armadale, Victoria ... 1894
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Fison, Rev. Lorimer, M.A., Essendon, Victoria ... 1889

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Gatliff, J. H., Commercial Bank of Australasia, Lygon-street, Carlton 1898
Grant, F. E. Union Bank, Collins-street 1898
Green, W. Heber, B.Sc., Albany Crescent, Surrey Hills, Victoria 1896

Herman, Hyman, B.C.E., Department of Mines, Melb. ... 1897
Holmes, W. A., Telegraph Engineer's Office, Railway Department, Melbourne 1879
Hubbard, J. R., Perth, West Australia 1884

Ingamells, F. N., Observatory, Melbourne ... 1889

Jutson, J. T., 32 Bastings-street, Northcote, Victoria ... 1895

Kernot, Frederick A., 66 Russell-street, Melbourne ... 1881
Kitson, A. E., F.G.S., 372 Albert-street, East Melbourne 1894

Lambert, Thomas, Bank of New South Wales, Collins-street, Melbourne 1890
Le Souëf, Dudley, C.M.Z.S., Zoological Gardens, Royal Park 1894
Lidgey, E. A., Department of Mines, Melbourne ... 1894
Luly, W. H., Department of Lands, Treasury, Melbourne 1896

Maclean, C. W., 276 Walsh-street, South Yarra ... 1879
M'Ewan, John, 70 Swanston-street 1898
Melville, A. G., Mullen's Library, Collins-street east, Melbourne 1889
Murray, Stuart, C.E., Department of Water Supply, Melbourne 1874

Phillips, A. E., Box 396, G.P.O., Melbourne ... 1883
Pritchard, G. B., Mantell-street, Moonee Ponds, Victoria 1892

Robertson, E. J., 411 Toorak-road, South Yarra, Victoria 1895
Robinson, C. A., Lands Department, Treasury, Melbourne 1894
Rosenhain, Walter 1896

Sayce, O. A., Harcourt-street, Hawthorn 1898
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Shephard, John, 135 City-road, South Melbourne ... 1894
Smith, B. D., 30 Queen-street, Melbourne 1897
Stewart, C., Oxford Chambers, Bourke-street, Melb.... 1883
Strettle, W. S., B.C.E., Public Works Department, Perth, W.A. 1891

Thiele, E. O., Doncaster 1898
Tisdall, H. T., 7 Washington-street, Toorak 1883

Wallace, W., Mines Department, Treasury, Melbourne ... 1896
Wedeles, James, 231 Flinders-lane, Melbourne ... 1896

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K. Akademie der Wissenschaften	Vienna
K. K. Geographische Gesellschaft	Vienna
K. K. Geologische Reichsanstalt	Vienna
K. K. Naturhistorisches Hofmuseum	Vienna
K. K. Sternwarte	Prague

BELGIUM.

Académie Royale des Sciences de Belgique ...	Bruxelles
Société Géologique de Belgique	Bruxelles
Société Royale Malacologique de Belgique ...	Bruxelles

CANADA.

Canadian Institute	Toronto
Geological and Natural History Survey of Canada ...	Ottawa
Minister's Office (Militia and Defence)	Ottawa
Natural History Society of Montreal	Montreal
Nova Scotian Institute of Science	Halifax
Royal Society of Canada	Montreal

CAPE COLONY.

South African Museum	Cape Town
South African Philosophical Society, Observatory ...	Cape Town

CHINA.

China Branch of the Royal Asiatic Society ...	Shanghai

DENMARK.

Kon. Danske Videnskaberne Selskab.	Copenhagen

ENGLAND.

Agent-General of Victoria	London
Anthropological Institute	London
Balfour Library	Cambridge
Bodleian Library	Oxford
Bristol Naturalists' Society	Bristol
British Museum	London
British Museum (Natural History)	London
Colonial Office Library	London
Foreign Office Library	London
Free Public Library	Liverpool
Geological Society	London
Institute of Mining and Mechanical Engineers ...	Newcastle
Linnæan Society	London
Literary and Philosophical Society	Manchester
Liverpool Biological Society	Liverpool
Liverpool Literary and Philosophical Society ...	Liverpool
Manchester Museum, Owens College	Manchester
Marine Biological Laboratory	Plymouth
"Nature"	London
"Natural Science"	London
Owens College Library	Manchester
Patent Office, 25 Southampton Buildings	London
Philosophical Society	Cambridge
Physical Society	London
Radcliffe Library	Oxford
Royal College of Science	South Kensington
Royal Colonial Institute	London
Royal Gardens	Kew
Royal Geographical Society	London
Royal Microscopical Society	London
Royal Society	London
Statistical Society	London
University College	London
University Library	Cambridge
Yorkshire College of Science	Leeds

FRANCE.

Académie des Sciences, Belles Lettres et Arts ...	Lyon
Faculté des Sciences	Marseilles
Feuilles des Jeunes Naturalistes	Paris
Société des Sciences Naturelles de l'Ouest de la France (Museum)	Nantes
Société Nationale de Cherbourg	Cherbourg
Société Zoologique de France	Paris

GERMANY.

Gesellschaft für Erdkunde	Berlin
Jenaische Zeitsch. f. Medicin und Naturwissenschaft	Jena
Königl.-bäyer. Akademie der Wissenschaften ...	Munich
Königl. Museum für Naturkunde, Zoologische Sammlung	Berlin
Königl. Offentl. Bibliothek	Dresden
Königl. Preussische Akademie der Wissenschaften ...	Berlin
Königl. Sächs. Gesellschaft der Wissenschaften ...	Leipzig
Königl. Gesellschaft der Wissenschaften	Göttingen
Naturforschende Gesellschaft	Emden
Naturforschende Gesellschaft	Leipzig
Naturforschende Gesellschaft Bleichstrasse 59.	Frankfurt am M.
Naturhistorisch-Medicinischer Verein	Heidelberg
Naturhistorisches Museum	Hamburg
Naturwissenschaftlicher Verein	Bremen
Oberhessische Gesellschaft für Natur u. Heilkunde ...	Giessen
Schlesische Gesellschaft für vaterländische Cultur ...	Breslau
Verein für Erdkunde	Darmstadt
Verein für Erdkunde	Halle
Verein für Naturkunde	Kassel

HOLLAND.

Musée Teyler	Haarlem
Natuurkundig Genootschap	Groningen
Nederlandsche Botanische Vereeniging	Nijmegen
Kon. Akademie van Wetenschappen	Amsterdam
Société Hollandaise des Sciences	Haarlem
Société Provinciale des Arts et Sciences	Utrecht

INDIA.

Asiatic Society of Bengal	Calcutta
Geological Survey of India	Calcutta
G. V. Juggarow Observatory	Vizagapatam
Madras Literary Society	Madras
Royal Asiatic Society, Ceylon Branch	Colombo

IRELAND.

Belfast Natural History and Philosophical Society ...	Belfast
Royal Dublin Society	Dublin
Royal Irish Academy	Dublin
Trinity College Library	Dublin

ITALY.

Biblioteca Nazionale Centrale Vittorio Emanuele...	Rome
Museo di Zoologia ed Anatomia Comp., R. Università	Turin
Ministerio dei Lavori Pubblici	Rome
Reale Accademia dei Lincei	Rome
R. Accademia delle Scienze dell' Instituto ...	Bologna
Reale Accademia di Scienze	Palermo
Reale Accademia di Scienze, Lettere ed Arti ...	Lucca
Regia Accademia di Scienze, Lettere ed Arti ...	Modena
Società Geografica Italiana	Rome
Società Toscana di Scienze Naturali	Pisa
Zoological Station	Naples

JAPAN.

Imperial University	Tokio

JAVA.

Bataviaasch Genootschap van Kunsten en Wetenschappen	Batavia
Magnetical and Meteorological Observatory ...	Batavia

MAURITIUS.

Royal Alfred Observatory	Mauritius

MEXICO.

Ministerio de Fomento	Mexico
Observatorio Meteorologico Magnetico Central ...	Mexico
Observatorio Astronomico Nacional	Tacubaya
Sociedad Científica, "Antonio Alzate"	Mexico

NEW SOUTH WALES.

Australian Museum	Sydney
Astronomical Observatory	Sydney
Botanic Gardens	Sydney
Department of Agriculture	Sydney
Department of Mines	Sydney
Linnæan Society of New South Wales	Sydney
Parliamentary Library	Sydney
Public Library	Sydney
Royal Society	Sydney
Technological Museum	Sydney
University Library	Sydney

New Zealand.

Auckland Institute and Museum ... ... Auckland
Colonial Museum and Geological Survey Department Wellington
Museum ... ... Christchurch
New Zealand Institute ... . Wellington
Otago Institute ... ... Dunedin
Parliamentary Library ... ... Wellington
Public Library ... ... Wellington

Norway.

Bergens Museum ... ... Bergen
Videnskabs-Selskabet ... ... Christiania

Portugal.

Sociedade de Geographia ... ... Lisbon

Queensland.

Parliamentary Library ... ... Brisbane
Public Library and Museum ... ... Brisbane
Royal Geographical Society ... ... Brisbane
Royal Society of Queensland ... ... Brisbane

Roumania.

Institut Météorologique de Roumanie ... ... Bucharest

Russia.

Académie Impériale des Sciences ... St. Petersburg
Jardin Botanique Imperial ... ... St. Petersburg
Minister of Agriculture, St. Petersburg, c/o Russian Consulate ... ... Melbourne
Societas Scientiarum Fennica ... ... Helsingfors, Finland
Société des Naturalistes de l'Université de Kasan ... Kasan
Société des Naturalistes ... ... Kiew
Société des Naturalistes de la Nouvelle Russie ... Odessa
Société Impériale des Naturalistes ... ... Moscow
Société Impériale Russe de Geographie ... St. Petersburg

SCOTLAND.

Botanical Society	Edinburgh
Geological Society	Edinburgh
Royal College of Physicians' Laboratory	Edinburgh
Royal Physical Society	Edinburgh
Royal Scottish Geographical Society	Edinburgh
Royal Scottish Society of Arts	Edinburgh
Royal Society	Edinburgh
University Library	Edinburgh
University Library	Glasgow
Philosophical Society	Glasgow

SOUTH AUSTRALIA.

Parliamentary Library	Adelaide
Public Library and Museum	Adelaide
Royal Society of South Australia	Adelaide
University Library	Adelaide

SPAIN.

Real Academía de Ciencias exactas, físicas y naturaes	Madrid

SWEDEN.

Entomologiska Föreningen	Stockholm
Kongl. Universitets Bibliotek	Upsala
Kongl. Vetenskaps Akademi	Stockholm
Kongl. Vitterhets Historie och Antiquets Akademi	Stockholm
Kungl. Vetenskaps och Vitterhets Samhälle ...	Göteborg

SWITZERLAND.

Geographische Gesellschaft	Berne
Naturforschende Gesellschaft	Zürich
Schweizerische Naturforschende Gesellschaft ...	Berne
Société de Physique et d'Histoire Naturelle ...	Genève

TASMANIA.

Parliamentary Library	Hobart
Public Library	Hobart
Royal Society of Tasmania	Hobart

United States of America.

Academy of Natural Sciences	Davenport
Academy of Natural Sciences	Philadelphia
American Museum of Natural History, Central Park	New York
American Academy of Arts and Sciences	Boston
American Geographical Society	New York
American Philosophical Society	Philadelphia
Bureau of Ethnology, Smithsonian Institute	Washington
California Academy of Sciences	San Francisco
Cooper Union for the Advancement of Science & Art	New York
Denison University	Ohio
Department of Agriculture	Washington, D.C.
Field Columbian Museum	Chicago
Geological Survey	Iowa
Iowa Academy of Sciences	Iowa
Johns Hopkins University	Baltimore
Missouri Botanical Garden	St. Louis
New York Public Library	New York
Philosophical Society	Washington
St. Louis Academy of Science	St. Louis
"Science"	New York
Smithsonian Institution	Washington
Society of Natural History	Boston
Society of Natural Sciences	Buffalo
Texas Academy of Sciences	Austin
United States Geological Survey	Washington
University of California	Berkeley, Cal.
University of Kansas	Lawrence, Kan.
Wisconsin Academy of Sciences, Arts, and Letters	Madison

Uruguay.

Museo Nacional	Montevideo

Victoria.

"Age"	Melbourne
"Argus"	Melbourne
Athenæum	Melbourne
Astronomical Observatory	Melbourne
Australasian Institute of Mining Engineers	Melbourne
Chief Secretary's Office	Melbourne
Department of Mines and Water Supply	Melbourne
Field Naturalists' Club of Victoria	Melbourne
Free Library	Echuca

Free Library	Geelong
Free Library	Bendigo
Geological Society of Australasia	Melbourne
Gordon Technical College	Geelong
Government Entomologist	Melbourne
Government Statist	Melbourne
Medical Society of Victoria	Melbourne
Parliamentary Library	Melbourne
Pharmaceutical Society of Australasia	Melbourne
Public Library	Melbourne
Railway Library	Melbourne
Royal Geographical Society	Melbourne
Royal Mint	Melbourne
School of Mines	Ballarat
School of Mines	Castlemaine
School of Mines	Bendigo
School of Mines	Maryborough
School of Mines	Bairnsdale
School of Mines	Stawell
Prahran Public Library	Prahran
University Library	Melbourne
Victorian Chamber of Manufactures ...	Melbourne
Victorian Institute of Engineers	Melbourne
Victorian Institute of Surveyors	Melbourne
Working Men's College	Melbourne

WESTERN AUSTRALIA.

Observatory...	Perth
Geological Survey Office	Perth

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